Environment Canada Environnement Canada

Review and Evaluation of Adaptive Environmental Assessment and Management

Canada

Review and Evaluation of Adaptive Environmental Assessment and Management

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Acknowledgements

It is easy to judge and evaluate an innovation. It is far more difficult to conceive and to nurture the newborn ideas through their infant days when the potential is uncertain. Now that AEAM is in its teens and is contributing to the resolution of environmental and resource issues, the authors wish to acknowledge and thank the visionaries who are responsible for its development and implementation.

In truth this review is not the product of just the authors. The need for the review was perceived by Dr. John Wiebe of Environment Canada. In this production he served in the role of the "wise person", and made the review a reality. The report content comes from the collective experience, insight, and understanding of about 30 participants at a 3-day workshop convened to review and evaluate AEAM. Their dedication to the cause of effective resource management generated both the energy and the ideas necessary for this evaluation.

Finally we wish to thank: our colleagues in the U.S. Fish and Wildlife Service, Fort Collins, Co., for their generous contribution, the past users who took the time to complete project evaluations, and the reviewers who read the draft of this report and made valuable recommendations.

Preface

"If the Lord Almighty had consulted me before embarking upon the Creation, I would have recommended something simpler." (Alfonsa X of Castile, a medieval royal patron of astronomy (1)).

Alfonsa X of Castile's lament about the state of astronomical research in medieval times echoes true today in the context of research into the environmental management of resources. The bewildering complexity of environmental systems confronts investigators whenever there is an attempt to understand the impacts of man's activities. In short, biophysical and social systems are dynamic, almost unpredictable, and full of surprises. With each major perturbation, whether through a large energy development or through renewable resource management, come new surprises and new problems.

The scope and magnitude of the perturbations to environmental systems now occurring or planned is staggering. The potential for serious detrimental effects is real. However, the rapid pace at which a development scenario waxes and wanes, coupled with the shifting political and social context for renewable resource management, has begun to overstress the capabilities of organizations whose responsibility it is to regulate development or manage resources. Most of these organizations recognize that there is a problem; some recognize that they are part of the problem; while others may fail to perceive any problem exists.

Adaptive Environmental Assessment and Management (AEAM) can provide help to these organizations by applying the techniques of systems analysis and systems ecology to develop an understanding of the environmental system. Workshops can be used to overcome some of the problems inherent in inter-organizational and intra-organizational communication. Despite a track record spanning two decades, AEAM is often perceived as a new and innovative technology. As such, it is subject to the resistance common to all new technology within organizations. Policy research from a number of fields is revealing that individuals within an organization create barriers to innovation and change. This has been variously called territorial response, closing of the ranks or counterimplementation. Barriers to implementation are real and do present a formidable obstacle.

In response to environmental problems, countries and agencies within countries have erected institutional frameworks. These frameworks, for example NEPA in the United States and EARP in Canada, were developed to guide environmental planning associated with resource development. Similarly, complex management structures and research

organizations have been set up for renewable resources like fisheries and forests. These frameworks, while necessary, may restrict opportunities for change.

These frameworks set rules for the games within which organizations pursue strategies carried out through the tactics of the individual players. Any new idea must be implemented through these same tactics. A new idea that involves new strategies requires support from players at key strategic levels of an organization. In the short run, institutional frameworks are fixed, and will be more or less constraining, depending on the organization. In the long run, the rules of the game can be changed and if a new idea is sound and marketed well, it may bring about a change in the institutional framework.

Adaptive Environmental Assessment and Management is a powerful tool. It has been dependably successful at the tactical level. Its success at the strategic level is more sporadic and its ability to direct change in institutional frameworks is only just becoming realized. The challenge is to realize the ideals of AEAM and continue to adapt effectively in the face of complexity and surprise.

Executive Summary

Adaptive Environmental Assessment and Management (AEAM) is a collection of concepts, techniques, and procedures intended for the design of creative resource management and policy alternatives. Development of AEAM was initiated in the early 1970s, and since that time, the approach has been applied to over 60 projects. These applications have provided exposure to a wide variety of institutions, problems, and disciplines resulting in varying degrees of success. This report documents a critical review of AEAM that consisted of three stages: 1) a workshop which brought together practitioners, users, and senior policy designers; 2) case study evaluations by both practitioners and users; and 3) a synoptic analysis of AEAM procedures, literature and case studies.

Is AEAM Useful?

Success is an elusive quality that is difficult to measure. Within any large project it is nearly impossible to determine whether any given procedure has saved time or money. However, user opinion is a measure of credibility and use of the techniques. Therefore, users and practitioners were asked to evaluate success based on the objectives of AEAM projects. Objectives met successfully were communication, identification of issues and unknowns, information synthesis, and research planning. Moderate success was reported for policy analysis and the identification of impacts. A few users reported AEAM was ineffective for project management, but it was not recognized as an explicit objective by the practitioners. In general, success was most likely for objectives which were recognized by both the practitioners and users.

Even in successful projects some things do not work as well as expected. The most frequently cited inadequacies were: lack of institutional support, shortcomings in the model, insufficient or inappropriate data, and misunderstanding of the AEAM procedure. These issues are all likely to persist at some level; there could always be more support or a better model. Awareness of these inadequacies is only useful to the extent that it initiates effective action.

Institutions and People

"Institutional inertia" is the label for the set of circumstances which inhibit change. Stability and predictability are preferred whereas failures are feared. Innovations perceived as risky are avoided, especially if potential success won't be immediate. Although the structures and dynamics of institutions are not well understood, it appears that institutions are neither mechanistic nor predictable, rather they are controlled

by key individuals within the organization, irrespective of their formal position.

A few critical principles have been evident for years, namely that an adaptive design for analysis and management should be incorporated at the inception of a project, and the focus should be on people rather than technologies. In fact, the technology used should not only be defensible but also comprehensible. Time is required for ideas to develop and be absorbed into an institutional structure, and become effective only after transfer of ownership. In other words, the innovations must be requested by and belong to those who have the power to use them.

It has not been possible to develop a rule of thumb as to who will be the most effective individuals for implementing any given AEAM application. However, categories of people required are clear:

1. research scientists — to provide expertise in biophysical and social processes;

2. managers and decision makers — to provide relevance and chart a course through the institutional morass;

3. the "wise person" — an individual with professional understanding who has intuitive knowledge and who knows the institutional environment; and

4. practitioners — to act as modellers, information critics, intellectual leaders and professional facilitators.

It has also been recognized that most projects encounter counterimplementers who either play the useful role of devil's advocate or alternately, may sabotage any proposed change to protect their position. In either case, the recommendation is open and immediate communication, especially regarding controversial issues. Finally, the public is recognized as a significant group which could be involved through the ideas and procedures of AEAM.

Products and Processes

AEAM comprises an array of products and processes which can be appropriately combined, packaged, and presented to fit a variety of applications and circumstances. Simulation models provide a framework for synthesis and prediction and remain one of the most useful tools for coordination of effort and ideas. However, to ensure they achieve impact, models must be transparent and functional. The potential for model gaming within policy formation has barely been recognized and pursued.

Reports are valuable as a consensus document emerging from collective expertise. However, reports should be complemented with short presentations designed for the needs of the intended audience, with far more emphasis on clear and accurate summaries in written, oral, and graphical form.

Probably the most significant products of AEAM are the intangible ones: development of a common understanding, better communication, and clarification of uncertainties. AEAM has proven capability in the establishment of policy alternatives through creating an environment of action and partnership.

Applications for AEAM

Rarely can a particular application be formulated and implemented at a policy level primarily concerned with generating creative alternatives. Most applications are much more specific and narrowly designed. In particular, application types are often designated using names of standard elements within traditional management: research planning, impact assessment, synthesis, and management planning.

In one sense, these application types are theoretical. The practitioner and user evaluations did not identify past applications as belonging solely to any of the above types; rather each was unique in its mix of objectives. Application types can be similarly characterized by the mix of objectives they incorporate, either explicitly or implicitly. The recommended approach for evaluating AEAM for a new application is to identify the objectives to be met, and to evaluate the suitability of AEAM for those objectives.

Conclusions

The major conclusions emerging from the review are:

1. **Success is predictable:** Success is a composite measure of success in numerous objectives. On the whole, user opinion is favorable especially when longer term effects are considered.

2. **AEAM is useful:** It provides a series of tools which allow all concerned roles (e.g., scientists, policy advisors, public) to evaluate policy options in a framework relevant to their needs and interests.

3. **People are important:** The analyses and models must be tailored to better serve people.

4. **The right people can be involved:** Innovative and creative people have a knack for locating useful new approaches. The "right" people invariably want to be involved in an application.

5. **AEAM is compatible with current institutional environments:** AEAM creates a context which makes adaptation and change more feasible for institutions.

6. **AEAM is cost effective:** Although it is difficult to measure the cost of mistakes not made or unnecessary dollars not spent, AEAM represents an improvement in the current procedures for managing and protecting our resources.

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1. INTRODUCTION

Adaptive Environmental Assessment and Management (AEAM) is a collection of concepts, techniques and procedures intended for the design of creative resource management and policy alternatives. Development of AEAM procedures was initiated in the early 1970s by Dr. C.S. Holling and Dr. C.J. Walters and their associates at the University of British Columbia (UBC), Canada, and the International Institute for Applied Systems Analysis (IIASA), Vienna, Austria. The latter institution in particular allowed for a major expansion of the techniques and a deeper and more extensive incorporation of international experience. As a consequence, the book (2) describing the myths, procedures, and methods of AEAM, with selected case studies included authors from six different countries — Argentina, Canada, the United Kingdom, the United States, the USSR, and Venezuela. Throughout, Environment Canada and the Canadian Department of Fisheries and Oceans have provided financial and institutional support to the development and application of the procedures.

The approach has been applied by a number of academic, private, and government groups to over 60 projects. Most of those projects have been in Canada and the United States. But, key projects implemented in Argentina, Austria, Thailand, and Venezuela have been sufficiently effective to suggest their appropriateness in a variety of cultural and national settings at different stages of development.

These applications have exposed the procedures of AEAM to a wide variety of institutional mixes, types of problems, and blends of disciplines. Many of these applications have been successful; others less so. Given the number of applications and increased interest in the process, Environment Canada decided to sponsor a review of AEAM. This report is a summary of that review.

The purpose of this review is to evaluate the utility of the approach. Past successes and failures are appraised, and future directions and applications recommended. Institutional, people and packaging considerations are examined. An appraisal is made of the type and scope of projects suitable for AEAM applications.

What is AEAM?

Methods for dealing with resource management problems are required to bridge the gaps between knowledge and disciplines. The AEAM methodology recognizes that it is equally important to bridge gaps

between the various "actors" that are part of the problem. That includes not only the knowledge experts, but also the managers who are charged with operating a management scheme and the policy people who may serve in either advisory or decision making roles. Knowledge experts are basically driven by scientific goals. If they alone are involved, management constraints and policy purpose may be lost.

The AEAM methodology uses a workshop procedure to bridge both the knowledge and people gaps. A simulation model is used as a focus to develop links between people and to synthesize existing information. Key gaps in information are identified in the first workshop and priorities for filling these gaps are structured from both scientific and policy perspectives.

Usually an AEAM project starts with an initial meeting involving the workshop facilitators (about 5 people), the project leader, and some of his staff. Over a few days the general features of the problem are mapped out, responsibilities defined, and key participants identified for a first workshop which is advertised as a scoping effort. Approximately 20 to 25 people representing knowledge experts, managers, and policy people are brought together in the first workshop. During the workshop, a compendium of techniques and procedures is used to assure that the science is specifically directed to the problem. Both quantitative and qualitative techniques are used for synthesis, and workshop orchestration procedures assure interactive contributions by the participants. The 5 day workshop ends up producing some kind of model, a range of policy interventions, and a demonstration of the consequences of those interventions. However, its real purpose is to develop the links of communication, and to clearly identify the key areas of missing information, and the responsibilities assigned for that effort. Missing information may call for traditional research, for policy explorations, and for model revisions.

The first workshop can be followed by a period of independent work by the collaborating individuals which will lead to a second workshop and possibly subsequent ones in a phased sequence. Early in the sequence, workshops concentrate on technical issues, but later, they focus more and more on communication to policy advisors and the constituencies. The emphasis on communication enables an effective and logical move to implementation, either in a pilot project or a full-scale program.

AEAM's key features are as follows:

1. Ecological and environmental knowledge is incorporated with economic and social concerns at the beginning of a strategic analysis rather than at the end of a design process.

2. Since linked resource/social systems are dynamic rather than static and linear, techniques of simulation modelling, qualitative modelling and policy design and evaluation are chosen to reflect these features.

3. Scientists, managers, and policy people are involved and interact from the beginning and throughout the process of synthesis, analysis, and design so that learning becomes as much of a product as does problem solving.

4. Direction, design, and understanding are in the hands of those from the region who analyze, select and endure policies rather than in the hands of a separate group of analysts who lack the knowledge of needs, the responsibility and the accountability.

5. Although prediction can be improved, the uncertain and unexpected lie in the future of every design. Hence policies are designed both to explore opportunities and pitfalls as well as to fulfill immediate social needs.

The Nature of the Beast

There are probably as many definitions of AEAM as there are persons who have been exposed to it. Even reviews of the textbook (Holling, 1978) see it in many lights: "A methodology for making better environmental assessments" (4), "a tract on philosophy and logic" (5), or "environmental management from the perspective of systems analysis" (6). These views can be reconciled if one recognizes that AEAM consists of several components:

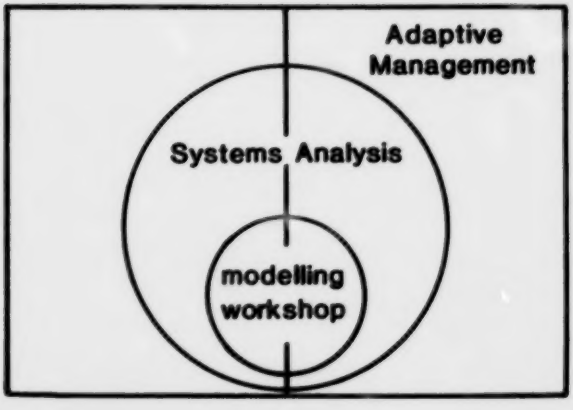


FIGURE 1.
Components of AEAM

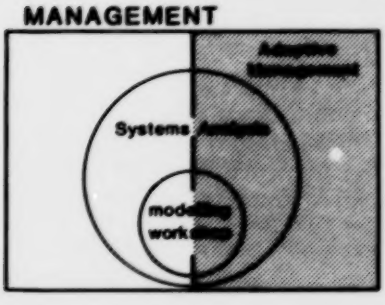
The large rectangle represents all resource and environmental management activities. Three components of AEAM that may be used in resource and environmental management are:

1. the concepts of **Adaptive Management** — the practice of recognizing uncertainties and designing policies or management strategies that can be used to learn and adapt in response to unexpected events, accumulation of knowledge, or active experimentation;

2. the methods of **Systems Analysis** — the collection of quantitative and qualitative tools used to characterize, mimic, and simplify dynamic systems; and

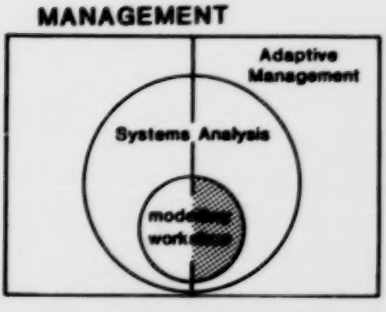
3. the procedures of **Modelling Workshops** — intensive, highly focused "brainstorming" sessions which develop and use simulation models to provide a forum for communication and collaborative problem solving.

Confusion arises when different aspects of these components are emphasized in any one application. This variation in emphasis has been commonly defined in six different ways:



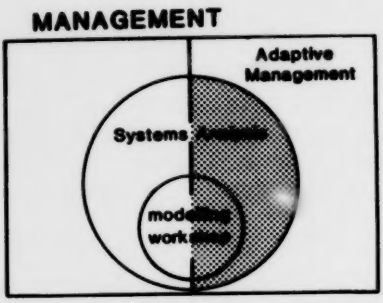
Adaptive Management

this comes closest to the original concept of AEAM, where modelling workshops and systems analysis tools are used for the development of adaptive policies for management;



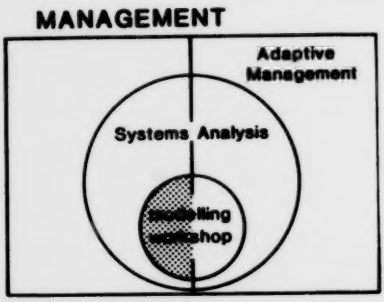
Adaptive Management Workshop

a workshop aimed at identifying appropriate management policies for a particular system;



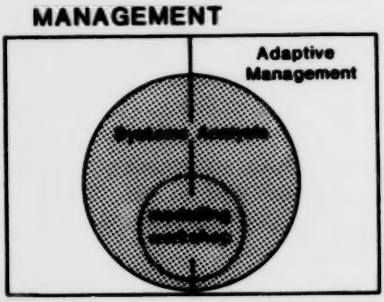
Scientific Management

an extended application of AEAM involving workshop procedures and systems analysis tools to improve management of a system;



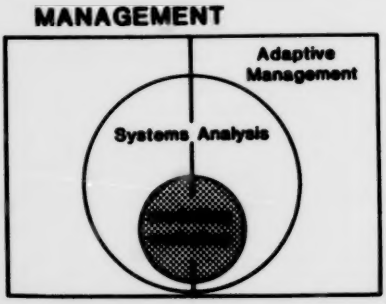
Scientific Workshop

a workshop directed at identifying conceptual uncertainties and research needs for a particular system;



Systems Analysis

this represents some of the earliest applications of AEAM when ecologists were learning systems analysis techniques to help focus research and design management policies; and



Modelling Workshop

a more recent definition which has resulted from the numerous cases where the application was limited to a single workshop with no follow up.

Conflicts, misunderstandings, and failures inevitably arise when it is not clear which definition is being discussed or which is appropriate for a specific application. In this report, "AEAM" will refer to *Adaptive Management* combined with *Systems Analysis* which includes all of the above models. When a more limited interpretation is required, it will be specified using the definitions presented above. Thus, AEAM is a collection of concepts, techniques, and procedures for the design of creative and effective management alternatives.

Structure of the Evaluation

The evaluation of AEAM presented in this report was developed in three steps. The first was a review workshop held in January, 1982 which examined the utility of AEAM for research planning, impact assessment, resource management and policy design, and project integration. The review workshop brought together:

- practitioners of AEAM: a private consulting firm, a government sponsored team, and university faculty and staff;
- users of AEAM: academic, industry, and government; and
- people with a senior perspective who offered criticism and advice to the first two groups.

For a participant list, see Appendix III.

The second step was the preparation of individual case study evaluations. This was done in two stages:

1. evaluations by practitioners; this included a statement of project objectives, investments in time, manpower and dollars, listing of actors, and a discussion of which objectives were achieved and what the failures and difficulties were.

2. evaluations by users; this included a listing of objectives, evaluation of success in each objective, participation, resultant effect on project, costs, and reasons for any failures.

The third step began with review and analysis of the workshop proceedings, critical literature, and case study evaluations and led to specific recommendations for future applications and research.

2. IS AEAM USEFUL?

Over the past decade the AEAM process has been applied to a wide variety of environmental and resource issues with varying degrees of success. Features which make AEAM an attractive and useful methodology for tackling complex environmental problems are:

- it provides an unfamiliar mix of expertise and interests which brings together different approaches and views of the world;
- it provides a forum within which people with different roles (e.g., scientists, managers, policy advisors, key constituents, etc.) can interact;
- it draws from experiences in other areas and issues that relate to the problem at hand; and
- it promotes understanding of the behavior of complex, dynamic systems.

With that capability, AEAM has been touted as appropriate for any situation, almost as a panacea. However, in reality, past applications have been a mixture of successes and failures. Remembering that a key tenet of AEAM is learning and adaptability comes from failure, a critical examination of failures is thus valuable and necessary for tailoring and adapting the procedures in the future. Hopefully, by recognizing failure, AEAM can evolve into something more usable, more credible, and ultimately, more successful. ("It has been said that a fool makes many mistakes, while a damn fool makes only one. Over and over again." (3))

Criteria for Success

HOW DO WE TELL?

The proof of the pudding is in the eating. In judging a pudding we use established criteria like appearance, smell, taste, and texture, and we recognize that people have different preferences. Similarly, to evaluate the success of AEAM we need to determine what criteria to use, and in what context to make the evaluation.

Criteria for success in environmental management are difficult to define. Policies are often ill-defined or poorly articulated; and even when they are well-defined, it is difficult to evaluate success. Specific

goals or objectives are required to use as standards against which success can be evaluated. In establishing criteria for evaluation of AEAM, objectives of past AEAM applications were reviewed. Out of this review came the following objectives for the evaluation:

- *Identification of Issues and Unknowns*

  defensible separation of significant from insignificant issues and recognition of gaps in data and knowledge

- *Identification of Impacts*

  articulating specific outcomes which may result from a development

- *Communication*

  increased communication between researchers, managers, and users leading to a common understanding and cooperation

- *Information Synthesis*

  an integrated analysis which may include a functional simulation model that depicts the dynamics of a system

- *Research Planning*

  development of an integrated and cost effective research plan

- *Policy Analysis*

  focused evaluation of alternative options, potential impacts, and a prescription for future strategies

- *Project Management*

  flexible, iterative procedure which encourages new insights and adaptation throughout the process

The criteria associated with the above objectives all have implicit in them the word "better"; that is, these products will be better, (or will be easier to attain) through the use of AEAM rather than traditional methods. Tangible measures for better have not been specified and therefore, remain subjective judgements. Furthermore, not all of the criteria pertain to tangible products; many are processes, and it is difficult to compare the effectiveness of these to traditional procedures.

IS AEAM BEING USED?

Another dimension of success is internalization of the results of AEAM within the user organization. Internalization can be recognized when:

- an institution comes to recognize the product as their own;

- the results of AEAM (e.g., a suggested change in policy or research plan) are implemented and said to come from within the workings of the institution, rather than a direct result of AEAM; and

- the user adopts the process as his own, develops an internal expertise, and continues to apply AEAM after a particular project.

It is difficult for AEAM practitioners to accept internalization as a sign of success, particularly when there is less and less call for their expertise. Such phenomena are, however, indicators that institutions and persons within those institutions have accepted AEAM and recognize sufficient merit in it to use it as a part of doing business.

Transfer of the process is encouraged by one of the basic attributes of the AEAM process — namely it's adaptive. Inherent in this is the need for transparency to ensure that all those involved learn to understand the system and become intimately familiar with the strengths and weaknesses of the analysis. By so doing, AEAM facilitates a procedure whereby research, management, and policy can be continually evaluated and redesigned by all participants. In other words, AEAM is designed to capitalize on failure as well as success. This does not allow a clear comparison with other processes which also have failures but tend to hide them in a complex morass of data and reports understood by a select few. (It has been suggested that a possible criterion of success of AEAM could be the number of failures encountered and adapted to during the course of the application.)

The AEAM attributes of transferability, adaptability and capitalization on failure, make criteria for success particularly difficult to define and measure.

DOES AEAM SAVE TIME OR MONEY?

However useful the results of AEAM may be, the process may be impractical if it either takes too long or costs too much. Although cost is a standard measure of value, it is a very difficult criterion. Not only is it difficult to specify the actual cost of an application, but also, many of the benefits are elusive and difficult to quantify. In particular, it is difficult to measure the cost of mistakes not made or unnecessary research dollars not invested.

For example, in applying AEAM to research planning, researchers are asked to synthesize available data and concepts before they design their experiments and collect new data. It is undoubtedly more expensive initially to do this, but in the long term, savings are accrued in the

identification of which data are critical, integration between individual efforts, and in avoiding redundancy with past studies. For example, the managers of the Barrier Island Lagoon ecological processes study (Table 1, item 3) reported a savings of $150,000 through the use of AEAM procedures.

Nevertheless, AEAM does appear expensive since it has a high upfront cost that invariably prompts the potential user to seriously question AEAM's utility, especially when he feels the status quo works. Paying for something new, which may or may not work, is a risk that many managers do not wish to take.

HOW LONG TILL SUCCESS?

Time is a critical component in evaluating the success of AEAM applications from both the perspective of tenure of commitment to the process and delays in the indicators of success.

The appropriate timescale for achieving success depends on the scope of the project and the objective being considered. For example, where the intent of the application is research planning, success could be measured as soon as the research is implemented; that is within a few months. If there is an ongoing research program, success would be measured over the timescale of the program, which could be several years. Similarly, model transfer should not be evaluated for 1 to 3 years, and successful policy change would not be visible until it has had time to overcome institutional and political inertia (1 to 5 years).

Other objectives show immediate results. In particular, participants often leave initial workshops feeling satisfied with the enhanced dialogue between participants, the established level of systems understanding and the identification of issues and uncertainties. Although these are key features of AEAM, ultimately it makes no difference how people feel if they do not take action. The values tend to dissipate when there is no commitment to continue the process. Several reviewers suggested that, in fact, this commitment is the critical factor in success. Where there is a desperate need for change, people will utilize the process and achieve success. The most significant success, that is, the generation of more creative and ultimately effective management options, derives from the long term process of review, refinement, experimentation, and redesign.

Evaluations

PAST EVALUATIONS

Following in the wake of over sixty direct applications of AEAM are a large number of reports, reviews, and scientific papers. Many of these are well documented in the scientific literature (1, 8, 9, 10, 11).

More recently, a number of writers have evaluated the results of AEAM in a number of case histories (9, 10, 12, 13, 14); some by practitioners (9, 10, 12); others, by users. In all cases, the writers drew lessons from the application and presented a critical but positive review. Another set of writings about AEAM is the review of the book *Adaptive Environmental Assessment and Management*, (2) edited by Dr. C.S. Holling. The book, which encapsulates much of the philosophy and techniques, as well as five case studies of AEAM, has been reviewed in 4, 5, and 6. Another source of review came from the evaluation of the Barrier Island Lagoon Study carried out for the U.S. Outer Continental Shelf Environmental Assessment Program (17 and 18).

All of these reviews provide a rigorous external evaluation of the AEAM process and indicate that it has been successful and can be successful in the future. The reviews by the practitioners and users are more in depth and represent a critical internal evaluation. Although these reviews turn up many problems in implementing project results, an examination of the reasons does not reveal anything inherent in the AEAM process that makes its implementation more difficult than any other new technology.

CURRENT EVALUATIONS BY PRACTITIONERS AND USERS

Prior to the workshop being convened in January, 1982, the groups currently active as AEAM practitioners were requested to summarize their major projects (Table 1; Figure 2) with emphasis on objectives, successes, and failures. These project reviews, summarized in Appendix II, provided information for an analysis of many AEAM applications and their success. The striking result was that no application had a single objective, and that success had to be judged with respect to each of many objectives. Consequently, a questionnaire was designed that requested specification of the objectives, the degree of success in each objective, the initial and ultimate usefulness of the application, and reasons for any failures.

Practitioners reviewed 21 AEAM applications and the users submitted a total of 32 responses for 22 applications (Table 1). For the purposes of analysis, the user responses were treated as independent observations. Since multiple responses were received only for the more recent projects,

TABLE 1.

Some major applications of the AEAM process. Year refers to the year in which use of AEAM was first initiated. Applications evaluated, for this report, by users are marked (X) under the column "U"; those by practitioners under the column "P".

User	Project	Year	Evaluated by U	Evaluated by P	Location
1. Environment Canada	Eastern Spruce Budworm Research and Management policy planning	1972	X		Fredricton, N.B.
2. Austrian Man and Biosphere program and the International Institute for Applied Systems Analysis	Environmental and Social Consequences of development in the Alpine Village of Obergurgl	1974	X		Obergurgl, Austria
3. Arctic Project Office NOAA	Ecological Processes Study of the Barrier Island Lagoon	1976	X		Barrier Islands, Alaska
4. Canadian Department of Fisheries and Oceans	Management of West Coast Salmon	1976	X		Vancouver, B.C.
5. U.S. Fish and Wildlife Service	Charles M. Russell Refuge Management	1978	X		C.M. Russell Refuge, Montana
6. Environment Canada	Porcupine Caribou Herd	1978	X	X	North Slope, Alaska and N. Yukon
7. U.S. Geological Survey	Truckee-Carson River Quality Assessment	1978	X	X	Reno, Nevada
8. B.C. Council of Forest Industries	The Assimilative Capacity of Aquatic Environments for Pulp Mill Effluent	1979	X	X	Vancouver, B.C.
9. Alberta Oil Sands Environmental Research Program	An Adaptive Environmental Assessment Approach to the Effects of Development of the Alberta Oil Sands	1979		X	Ft. McMurray, Alberta
10. California Water Policy Center (USFWS)	Sacramento-San Joaquin Water Management System — Integrated Management	1979	X	X	Sacramento, Calif.
11. U.S. Forest Service	Western Spruce Budworm Research Planning	1980	X	X	Portland, Ore.
12. Mekong Secretariat, U.N. Bangkok, Ford Foundation	Application of AEAM to the Nam Pong Environment Management Research Project	1980	X	X	Bangkok, Thailand
13. B.C. Hydro and Power Authority	Mackenzie Delta Modelling for Environmental Studies of the Liard River Hydroelectric Development	1980	X	X	Mackenzie Delta, NWT
14. NOAA/OCSEAP/ BLM	Research Planning related to effects of Bering Sea Petroleum Development on King and Tanner Crab populations	1980	X		Bering Sea
15. Ontario Ministry of Municipal Affairs and Housing	Integration of the Lakeshore Capacity Study	1980	X	X	Toronto, Ontario

	User	Project	Year	Evaluated by U	Evaluated by P	Location
16.	National Power Plant Team (USFWS)	Acid Precipitation — Research Needs	1980	X	X	Ann Arbor, Michigan
17.	Cooperative Agreement between Assistant Secretary for Fish, Wildlife and Parks and Governor's Office, North Dakota	Wetland Preservation and Protection in North Dakota	1980	X	X	Bismark, DA
18.	Wyoming Game and Fish Department	Resource Development and Management in Jackson Hole, Wyoming	1981	X	X	Jackson Hole, Wyoming
19.	Petro Canada	Development and Application of a Site Selection Methodology for an LNG Facility on the coast of British Columbia	1981		X	Calgary, Alta.
20.	Environment Canada	Beaufort Sea Hydrocarbon Development — Scenario Evaluation	1981		X	Beaufort Sea
21.	Great Lakes Fisheries Commission	Training in Adaptive Environmental Assessment and Management	1981	X	X	Sault Ste. Marie, Michigan
22.	Biological Services Program, U.S. Fish and Wildlife Service	Development of the Beluga Coal Resource in Alaska	1981	X	X	Cook Inlet, AK
23.	Environmental Protection Agency	Potential Impacts of Drilling Muds and Cuttings on the Gulf of Mexico Marine Environment	1981	X	X	Penascola, Fla.
24.	U.S. Bureau of Land Management	Saval Ranch Project — Research Planning and Management of Alternate Cattle Grazing Schemes	1981	X	X	Elko, Nevada
25.	Environmental Protection Agency	Environmental effects of Developments in Mobile Bay, Alabama	1981	X	X	Mobile Bay, Ala.
26.	B.C. Ministries of Forests and Environment	Research Planning for the Integrated Wildlife Intensive Forestry Research Program	1981		X	Victoria, B.C.
27.	Ontario Ministry of Natural Resources	Application of AEAM to Fisheries Management and Acid Rain Research in the Algonquin Assessment Unit	1981		X	Toronto, Ontario
28.	Canadian Department of Fisheries and Oceans	Research Needs and Data Base Management for Acid Rain Studies in Eastern Canada	1982			Toronto, Ontario
29.	U.S. Forest Service	Development of Integrated Management Model of Forest, Fisheries, Wildlife Resources in Southeast Alaska	1982			Juneau, Alaska

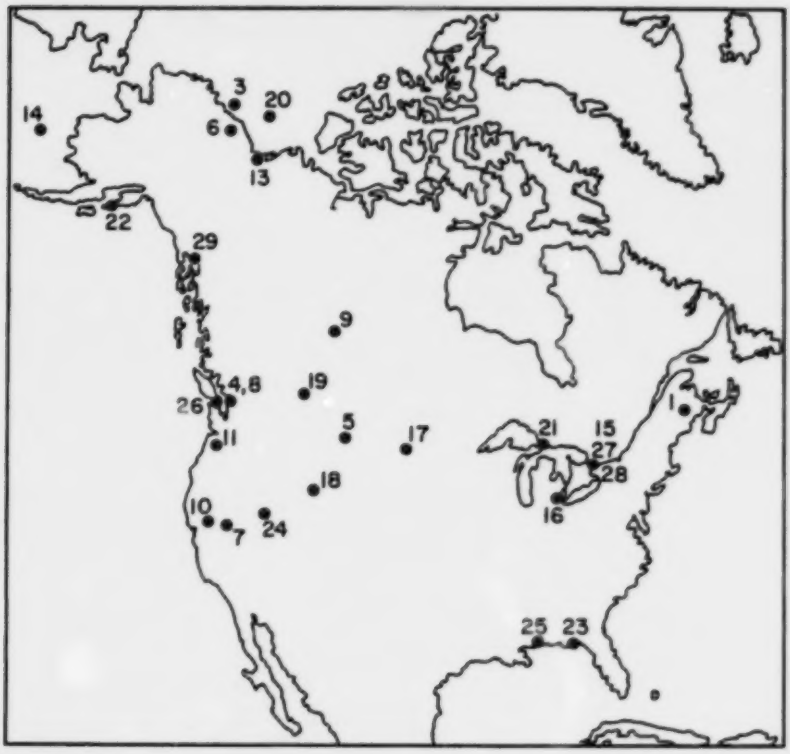


FIGURE 2.
Locations of some major North American applications of the AEAM process. Numbers refer to the projects named in Table 1.

there will be a slight weighting in favor of the more recent applications of AEAM. The following is an analysis of these responses:

(a) *Objectives of the Applications*

The objectives cited by the users and practitioners were broadly grouped into the following headings.

- Identification of Issues and Unknowns
- Identification of Impacts
- Communication
- Information Synthesis
- Research Planning
- Policy Analysis
- Project Management

Both practitioners and users listed an average of 3.3 main objectives per application. Users further list an average of 2.2 auxiliary objectives with the result that, on average, each application was expected to serve up to 5.5 different objectives.

What were the main objectives of past applications? As mentioned above, it depends on who is asked (Figure 3). For users the most common were identification of issues and unknowns, and communication — with identification of impacts, information synthesis, and research planning cited in at least 50% of the projects. Users cite policy analysis and project management in only 20% and 10% of the project applications respectively. Practitioners meanwhile do not even mention project management in spite of the stress they place on adaptive management. Evidently, they have not assumed (or feel they cannot assume) responsibility for managing the projects. For practitioners, the four most common objectives were identification of issues and unknowns, communication, information synthesis, and policy analysis.

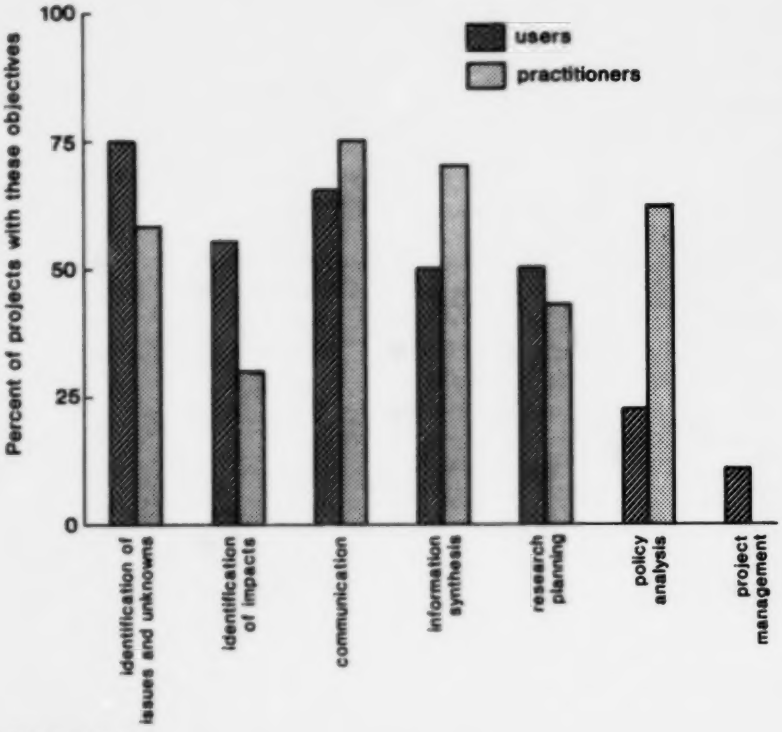
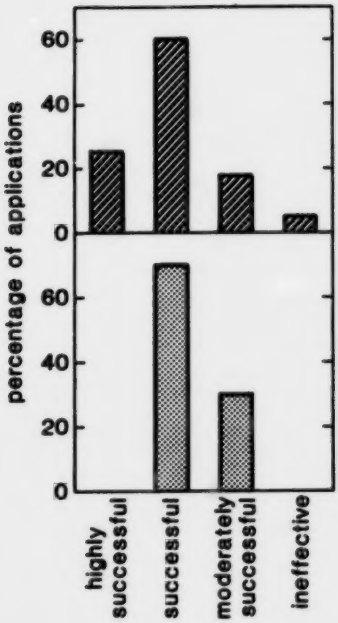


FIGURE 3.
Objectives in past applications of AEAM. More than one objective may apply to an application; user and practitioner perceptions were sampled independently.

The differences between the perceived objectives of the users and practitioners are instructive. For example, the practitioners cited information synthesis in 20% more of the projects than the users, with the qualitative commentary "the users want it". However, the most striking differences were in the identification of impacts (users cited it almost twice as often) and policy analysis (practitioners cited it almost three times as often). These differences in interpretation of objectives were dramatically reflected in the evaluation of success with respect to each objective; success was least likely in those objectives where the alignment between user and practitioner was most tenuous (see below).

(b) *Success of Each Objective*

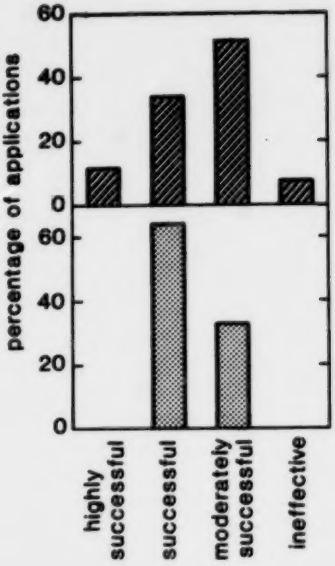
Since the questionnaires did not specify criteria for the evaluation of success or failure, the evaluations were based on personal and informed judgement. Although admittedly subjective, these judgements do, in fact, help determine choice and direction. The following histograms indicate the reported level of success for each objective as provided by the users (top graph) and practitioners (bottom graph).



Identification of Issues and Unknowns

The consensus was that AEAM is successful in achieving this objective.

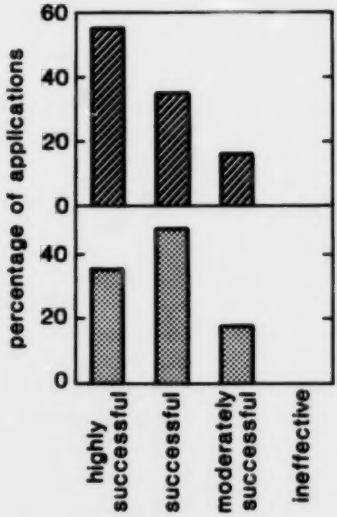
Evaluated by 24 users (top) and 12 practitioners (bottom)



Identification of Impacts

This was one of the objectives for which there was little alignment; more users than practitioners considered it to be an objective of the applications. It is not too surprising that users tend to see this as only a moderately successful objective — they were not receiving full support from the practitioners in achieving the result. Unfortunately, this analysis does not help decide whether AEAM is inherently suitable for addressing the objective of impact identification.

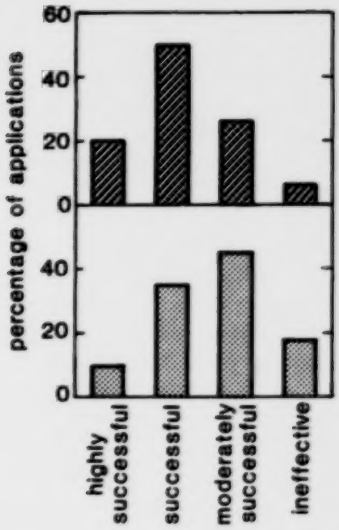
Evaluated by 18 users (top). Considered as an objective by 6 practitioners but evaluated by only 3 (bottom)



Communication

The objective of communication received the strongest positive response. Both practitioners and users judged communication to be ***highly successful*** in a large proportion of applications.

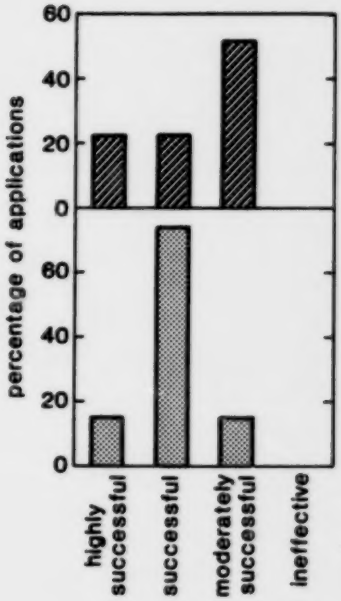
Evaluated by 21 users (top) and 16 practitioners (bottom)



Information Synthesis

Practitioners have historically played down this role for modelling workshops. In their experience, attempts to synthesize existing information, or information resulting from a long term research project, have always revealed significant gaps. Therefore, the attitude of the practitioner is that the AEAM process would be more appropriate at the start of a project; in other words, for identification of issues and unknowns, communication, and research planning. However, the evaluation by users indicates that they are generally satisfied with the synthesis which was achieved. In other words, the methods of AEAM may be among the best available for this application.

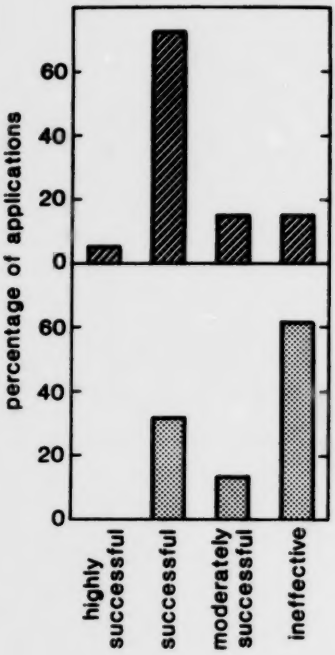
Evaluated by 16 users (top) and 15 practitioners (bottom)



Research Planning

Although both users and practitioners viewed this as a successful objective, practitioners showed more enthusiasm. It may be that from the user's perspective, traditional methods have so far been reasonably successful in planning research; any data gaps which would be unveiled by a modelling approach would not be noticed at the planning stage — thus, the benefits of this approach are not immediately visible to the user. Furthermore, cost effectiveness of the workshop versus inappropriate research done is difficult to measure.

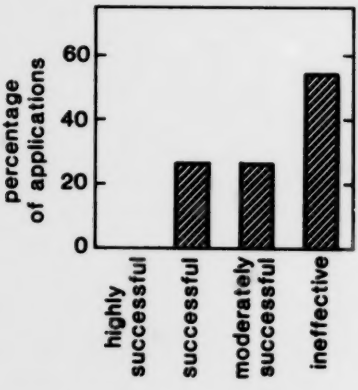
Evaluated by 16 users (top) and 9 practitioners (bottom)



Policy Analysis

At least two things contribute to the disparity in evaluation by users and practitioners. Users were fairly well satisfied with the policy analysis they achieved when that was their objective. Practitioners saw it as an objective in many more applications (see Figure 3) and they were disappointed in the results when their user "wasn't even trying". Secondly, the user is probably a better judge of how much his policy information has been guided by the AEAM application. In several cases, policy analysis was evaluated by the user to be successful while the practitioner felt it was ineffective. Thus, there was a lack of agreement as to whether policy analysis was an objective in the application and whether it was successful.

Evaluated by 7 users (top) and 12 practitioners (bottom)



Project Management

The sample size for this objective was very small, but it is significant to note that it was not successful for half the users, and that the practitioners did not even think it was an objective.

Evaluated by 4 users.

(c) *Is AEAM Successful?*

By pooling all the user evaluations across all objectives, an overview of the success of AEAM in past applications was generated (Figure 4). Clearly, the consensus is that AEAM was successful, with some moder-

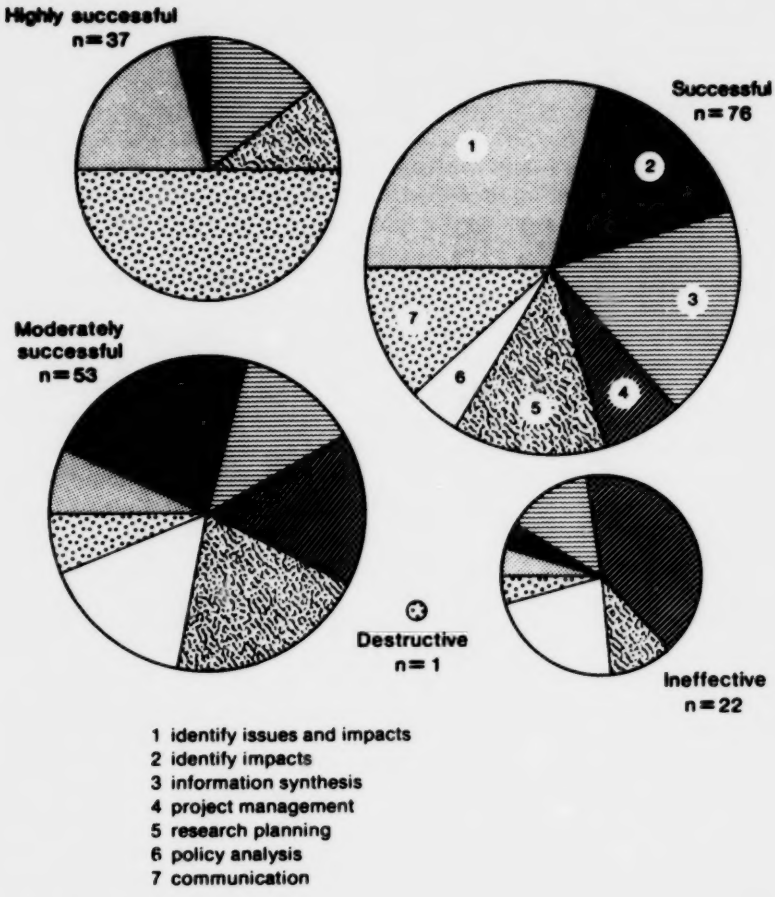


FIGURE 4.
User evaluation of success in past applications of AEAM. Area of circle indicates proportion of evaluations in each success category; stippling indicates to which objective the success was attributed.

ate successes, some highly successful applications, a few ineffective ones, and one evaluation (½%) as destructive for one objective in one application.

In general, the objectives at each success level are fairly evenly distributed with a few exceptions. Communication is responsible for half of the highly successful applications, identification of issues and unknowns has a large role in the successful applications, and project management makes a major contribution to the ineffective applications.

(d) *Time Dynamics of Success*

Reviewers of this report suggested that the reason why policy analysis does not appear more successful is that it takes several years to implement a new policy and thus realize its results. This observation certainly appears to be true when evaluating the overall usefulness of an application. Older applications on average are rated as more effective than recent applications (Table 2). Applications reported as highly innovative had an average age of 4.75 years whereas useful and indifferent results are reported for ages of 1.7 and 1.6 years respectively.

TABLE 2.
Effectiveness now of having used AEAM in project.

Evaluation by user	Average age of application (Years)	Number of Applications
highly innovative	4.75	8
useful	1.7	17
no change	1.6	3
disruptive	1	1

These data could be interpreted to say that where the application was highly successful, it persisted; however two factors indicate that this is not so. First, age was calculated from the inception of the application to the present regardless of whether it was actively pursued. Secondly, further analyses show that there is actually a time dynamic for the perceived usefulness of an application.

Figure 5 illustrates the history of user evaluated successes. In those cases where initial appraisal was high, the pattern is consistent in that a drop in enthusiasm to useful followed within a year. Those projects which have had time to mature are re-experiencing a sense of high value. Where the initial effectiveness was evaluated as useful — that is how it tended to stay over the lifetime of the project. In those cases where no effect was attributed to the first workshop, there was a noticeable tendency to improve with 42% of those projects eventually being regarded as highly innovative. Of the two projects rated at no effect after several years, one had absolutely no follow up, and the other actually reported a combination of useful and disruptive effects. Only two projects were considered initially disruptive (of these, one was truncated, and the other eventually came to be regarded as highly innovative). In summary, if it starts high, it drops, then returns to being high; if it starts as useful, it stays that way; and if it begins with skepticism, it gets better — often to the point of enthusiasm.

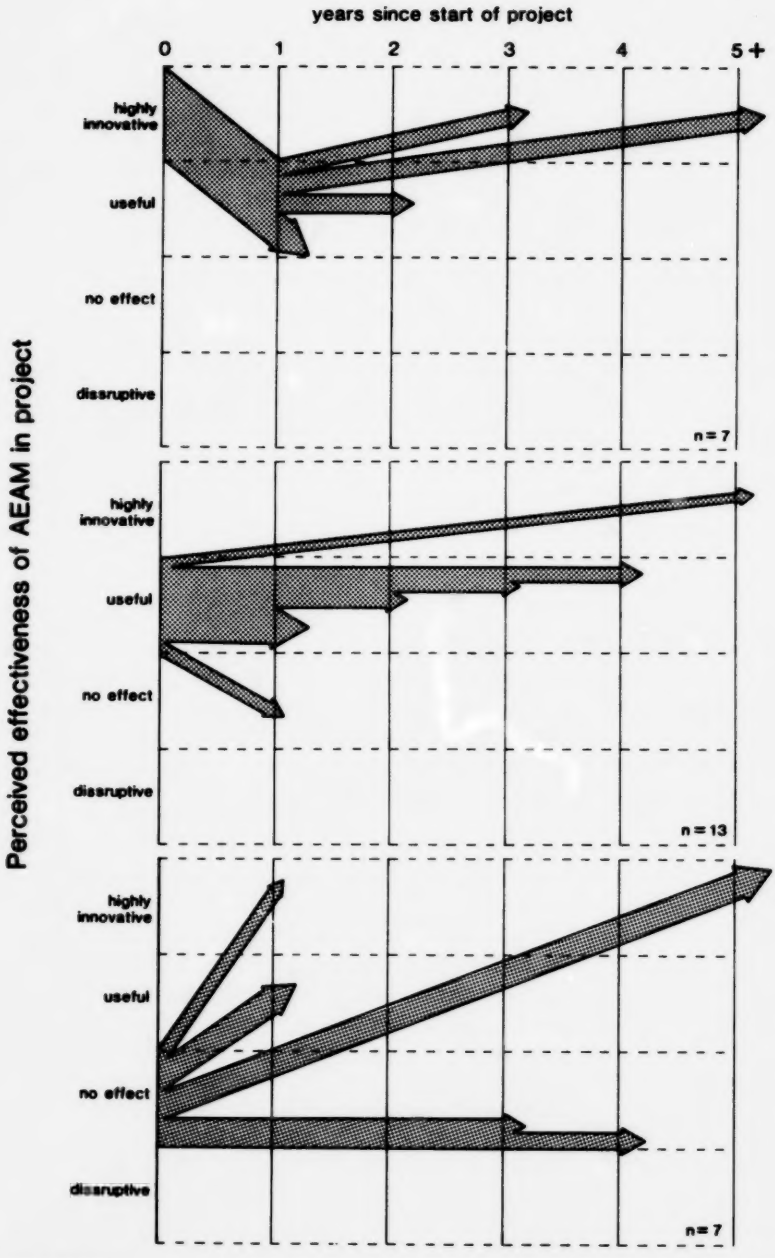


FIGURE 5.

History of success in AEAM applications as evaluated by users. Each arrow indicates what has happened over time to applications given an initial judgement of success. Arrow width is proportional to the number of projects following each trajectory.

(e) *Reasons Cited for Failures*

Even when an application is regarded as generally highly successful there are always some things which did not work out as well as expected. Rationalizing these failures is a normal response; and since these evaluations are totally subjective (i.e., no experiment has been conducted to test the assumed reasons) it is not possible to determine whether there is a popular rationale or whether a change in these factors will lead to better performance. However, clearly these suggestions are the first place to look and since there was such strong agreement between users and practitioners (Figure 6), it is reasonable to assume that these evaluations do comprise a realistic view of how the world works.

Four reasons were cited for failure in about half of the projects: lack of institutional support, model inadequacies, data inadequacies, and misunderstanding of AEAM concepts or procedures. The technical issues of model and data inadequacies are likely to persist at some level; there could always be a better model or more appropriate data. Specific inadequacies of the models can certainly be corrected (i.e., all those that relate to the model being too complex and not available for gaming and policy analysis). It is clear that in a workshop a simpler working model is more desirable than a detailed non-functional one.

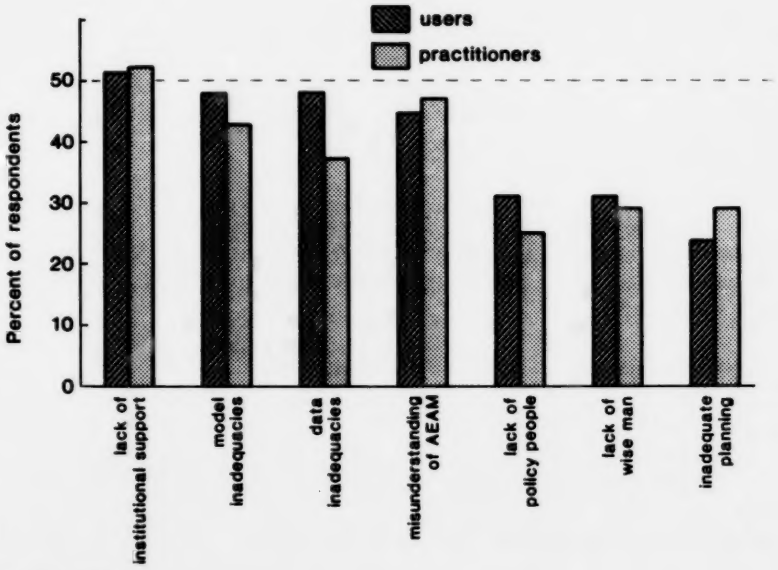


FIGURE 6.
Reasons for failures within applications as independently cited by users and practitioners.

Misunderstanding AEAM is a failure which the practitioner can take responsibility for and rectify in future contacts. The methods for this are not clear, but once the commitment to improve is in place, various experimental and adaptive approaches are available. In fact, the content of this review will, in itself, help serve that need.

The lack of institutional support may be alleviated by the realization of long term benefits available to institutions. Fifty percent of the projects did experience adequate support; and that is actually an encouraging number for an innovative procedure.

Other reasons cited for failure in 25-30% of the applications were lack of policy people, lack of a "wise man", and inadequate planning before and after the project. Regarding planning, hindsight is always better than foresight and hopefully the lessons emerging from poor planning are being internalized.

As for the lack of appropriate people, it is clear that project success depends on the involvement of key people. The difficulty is locating and enrolling these individuals. This is discussed in more detail in Chapter 4.

So, in answer to the question, "Is AEAM successful?", the answer is "yes". It doesn't provide solutions, but it does provide communication between groups, understanding of issues and unknowns, synthesis, and planning. Although policy analysis is not explicitly utilized, the long term successes imply that this attribute is actually a hidden value in most applications.

Applications of AEAM

As mentioned in the introduction, a three day workshop was held in Parksville in January, 1982 to review and evaluate the AEAM process. As part of that workshop, four broad areas of potential application were identified:

- Environmental Impact Assessment
- Research Planning
- Resource Management and Policy
- Project Integration and Synthesis

On the second day, four participant subgroups were identified and each assigned the task of evaluating the utility of AEAM within one of the

application areas. The results of those discussions are presented in Appendix I and are summarized here.

ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

Although AEAM has yet to be fully tested in the context of EIA, the participants felt AEAM has great potential to contribute to the EIA process. The major phases of the EIA process, as practiced in Canada and the United States, were captured in a generalized model (see Figure A1, Appendix I), and served as a focus for discussion.

(a) *Policy and Planning*

Modelling workshops were deemed appropriate at this stage. The whole thrust of this first step in an EIA should be focused on evaluating options and identifying uncertainties, the key benefits of modelling workshops.

What is unique about using modelling procedures at this stage is that it allows the user to integrate information, pose various scenarios, and answer "what if" questions with complete knowledge of the constraints and high profile issues. The gaming aspects of the model building also provide a powerful tool for evaluating system sensitivities, improving institutional understanding of future needs, and enhancing internal communications.

(b) *Preliminary Assessment*

The objectives of using AEAM at this stage would be to further refine the key issues, develop ecological syntheses, and clarify what is relevant and irrelevant.

The major risk associated with applying modelling workshops at this stage is the emphasis on system simplification which could result in a misidentification of data needs, and issues. However, this problem is not unique to AEAM. It is crucial at this stage to establish credible criteria for screening the options and to construct a defensible rationale for what is excluded from the analysis.

(c) *Scoping and Guidelines*

From the perspective of applying AEAM, this stage is effectively a continuation of the preliminary assessment stage, only now the public is involved. The major objectives are first to establish communications with the public and other interest groups and second, to design the guidelines for the formal assessment.

Since any interested party can become involved at this stage, what may be appropriate is a collection of workshops at different locations within the impacted region. The benefits of using this approach would be better communication and interaction between all interested parties thereby helping to diminish cross interest suspicions and confrontive strategies. The result would be an integrated analysis and a collaborative identification of issues that could be iteratively refined through a sequence of workshop/meetings.

(d) *Formal Assessment*

The formal assessment is the longest part of the EIA process, often taking a number of years. The major benefits to the proponent of using AEAM at this stage are coordination of effort and evaluation, and a better understanding of the systems dynamics thereby allowing the analysis to be more prescriptive than descriptive. This allows alternative strategies to be analyzed quickly.

(e) *Monitoring and Regulation*

The AEAM process is well suited to this stage of the EIA process, especially in evaluating the effects on unregulated issues (for example, socio-economic issues). In the past, there has been no rational approach for developing appropriate mitigation and/or compensation strategies for most of the biological and socio-economic impacts of development. AEAM provides a very innovative methodology for rationalizing this process and helping to solve these problems collaboratively.

In summary, a successful application would provide:

- a more integrated analysis
- a clarification of the significant issues and identification of the insignificant issues and why
- an evaluation of alternative options
- a prescriptive analysis rather than descriptive
- a coordinated, open assessment with continuity from start to finish
- an iterative reporting procedure demonstrating the proponent was open to new insights and could adapt and learn as the analysis progressed

RESEARCH PLANNING

The effectiveness of AEAM in facilitating the planning and management of research programs is well established. The major result, better and more cost effective research, is delivered in the form of a number of products, including a simulation model, a research plan, and reports. Other, less tangible products, include the development of a common understanding, increased communication amongst researchers and managers, a list of gaps in data and knowledge, and support for the research plan based on consensus and knowledge of its strengths and weaknesses.

The success of a research program can be enhanced by using AEAM throughout the course of a research program. During the initiation stage, AEAM should be used to help with problem definition and the determination of what and what not to consider. During the operation stage of the program, workshops held at regular intervals should be used to evaluate and redesign research. Finally, the procedures are appropriate during the termination stage to integrate the results of the program.

Throughout the process it is critical to include the right mixture of experienced and creative scientists along with managers and policy makers to ensure that a credible, rigorous, and usable product is produced. AEAM is extremely effective in ensuring that research is continually evaluated so that it may be adaptively redesigned in response to new knowledge and changing conditions.

Success is highly probable if AEAM is used at the appropriate time in the research program. The indicators of success in this context are savings in money, the quality of the research plan, and the quality of the research itself. AEAM does impact many of the decisions within the research program, especially those regarding the kind of research and the level of effort required. Review comments suggest that AEAM is a cost effective way of planning and managing research as well as ensuring that the research undertaken is cost effective.

RESOURCE MANAGEMENT AND POLICY

The term AEAM has been closely identified with the notions of resource management and policy in three ways:

(1) AEAM is adaptive management (experimental management by trial and learning);

(2) AEAM is a collection of collaborative problem solving methods by which adaptive policies and management decisions can be made; and

(3) AEAM is a modelling workshop at which resource policy issues are discussed.

The first definition of AEAM is too broad; adaptive management has historically been used without AEAM and does not require AEAM. The third definition is too narrow; AEAM would be ineffective if it were only a modelling workshop. The second definition is closer to the original definition of AEAM.

A central tenet important in discussing the role of AEAM in resource management and policy is that decisions are always made with a great deal of uncertainty. The design of many of the tools of AEAM (e.g., workshop) takes this uncertainty into account. Much of the experience with AEAM has been in the area of the definition and analysis of issues and therefore, that is where the procedures are best developed and the benefits most obvious.

AEAM is very useful for evaluating options in the context of dynamic systems behavior and the concerns of various interested parties. However, AEAM by itself likely does not generate options. Rather, it creates an environment in which creative options are *more likely* to be generated, and in turn, creates and uses tools which can be used to evaluate the alternatives. Practitioners cannot guarantee that a range of alternative management strategies or policies will automatically result from a workshop or any other AEAM application. What they can claim is that the tools of AEAM are designed to stimulate the thinking of participants into modes they rarely use and thereby enhance the possibility that interesting, unusual, perhaps even creative, alternatives will emerge. If alternatives do emerge, they can then be evaluated.

A recurring theme in assessing the utility of AEAM is the suitability of public involvement in AEAM when used for developing resource management and policy. Given the fact that the public are those who will have to endure the consequences of resource management and policy decisions, it is prudent and wise to make sure that the public is involved in AEAM through management and policy design. A standard modelling workshop may not be the appropriate medium for such involvement; other methods, such as simple gaming sessions, can be devised and used.

Implementing the policy results of AEAM has been historically difficult because the results often suggest a radical shift in policy or management away from the traditional. It is made even more difficult if the only

procedure the user wants is a single AEAM application such as a workshop; the practitioners are viewed as "hired guns" who come in, upset the normal course of business, frustrate participants, and then leave. A workshop should be preceded by preparation time and be followed by model refinements and sensitivity analysis. Although the primary responsibility for implementation of AEAM results into actual management and policy lies with the user, tools, such as policy workshops conducted by practitioners, make implementation easier. A greater range of AEAM application styles for a single policy design problem also enhances the probability that various parts of an institution become involved in the process and come to feel as owners of the result.

PROJECT INTEGRATION AND SYNTHESIS

There is no doubt that AEAM, in its various forms (i.e., modelling workshops, systems analysis, etc.), does integrate. The models built at workshops unite the understanding and concerns of the participants at the workshop. It is also these tools that AEAM practitioners use best. However, integration is also required between disciplines (i.e., scientific specialists, managers, engineers, etc.), people (from the field technician to the policy advisor to the public), and institutions, either among branches within a single agency or among different agencies.

The true question of integration is not one of integration within a single activity (e.g., a workshop), but integration of the results of an AEAM application into a wider audience of disciplines, roles, and institutions. In this respect, the discussion of integration is not a discussion of a specific use of AEAM; rather it pertains to the general success of the whole procedure.

In order for the integration to be successful it should be initiated at the same time as the project, and be continued throughout. Integration will occur more readily with continued interinstitutional and interdisciplinary contact focused toward a specific task. Further, each application should be tailored to the specific nature of the institutional and disciplinary mixes, as well as type and history of the problem. Every opportunity to be imaginative in creating opportunities and designing new methods should be capitalized on. And finally, results should not be expected instantaneously. Most institutions will adapt to innovative ideas and policies but will do so very slowly.

Summary

The criteria for success were defined as categories for which success can be subjectively evaluated in any particular application. These can be grouped into headings which are the various objectives for AEAM

applications. User questionnaires show that some of these objectives are more popular than others, and that some are more successful than others (Table 3). In general, the more frequently used objectives have been more successful.

TABLE 3.
Frequency of use and success of AEAM in various objectives. (Information summarized from Figures 3 and 4.)

Objective	Frequency of Use (% of Applications)	Successes Evaluated By User
Identification of issues and unknowns	frequent	successful
Identification of Impacts	moderate	moderately successful
Communication	frequent	highly successful
Information Synthesis	moderate	successful
Research Planning	moderate	successful
Policy Analysis	infrequent	successful
Project Management	infrequent	ineffective

Four application types were defined in order to evaluate the effectiveness of AEAM. It is clear that each application type has more than one objective, and that the relative importance of these objectives varies with the application. The question of whether AEAM is useful, or more specifically, whether to use AEAM for a new project can thus best be answered by listing the objectives of the project and noting how well AEAM can respond.

3. INSTITUTIONS

The Gordian Knot?

When asked to identify major reasons for failures of an AEAM application, the most popular response from both the practitioners and users was lack of institutional support. Over 50% of both groups flagged institutional support as a major issue (Figure 6). What is interesting is that where AEAM has had institutional support, it has been successful (see Chapter 2), although, usually the methodology itself was not adopted by the institution. (There are exceptions where the institutions did partially adopt the methodology: the eastern spruce budworm, western Canadian fisheries, and in the Austrian village of Obergurgl.)

The question is why is instutitional support a major problem? Participants at the workshop stated emphatically that senior policy makers are still seeking a process that will generate (and help evaluate) a range of creative, strategic options for environmental management and resource development, one of the major strengths of the AEAM methodology. The fact that this need has been persistent and intense over the last decade, without any apparent relief in sight, is symptomatic of a malady which can be termed institutional inertia (or social inertia (7)).

Causes of Institutional Inertia

Institutional inertia is a complicated way of saying no matter how hard you try, nothing seems to happen. Keen (7) gives four main causes of inertia in relation to information systems and they are very appropriate to the application of AEAM.

(1) Information is only a small component of organizational decision processes.

(2) Human information processing is experiential and relies on simplification.

(3) Organizations are complex and change is incremental and evolutionary; large steps are avoided, even resisted.

(4) Data are not merely an intellectual commodity but a political resource whose redistribution through new information systems affects the interests of particular groups.

As Keen (7) points out, the last cause is less passive than the others:

"Data are a central political resource. Many agents and units in organizations get their influence and autonomy from their control over information. They will not readily give that up. In many instances, new information systems represent a threat, and they respond accordingly." In other words, information is power.

Applications of AEAM have encountered some other major causes of institutional inertia:

(1) Large organizations strongly tend to worship stability and thereby attempt to maintain the status quo. Routine and imitative behavior (i.e., mimicry) reduces the costs of decision making and creates (in theory) predictability.

(2) Related to the previous point is a lack of entrepreneurial spirit within organizations. Risks are feared and, therefore, immediate success is a requirement for any innovation.

Basically, these latter two points can be distilled down to what may ultimately be the major cause of institutional inertia: fear of failure. A major aim of AEAM is to cultivate an environment in which individuals and organizations can adapt to the ever changing needs and directions precipitated within a dynamic society. Adapting to change is crucial to the long term survival of any organization since it is the dynamics and unpredictability of human and natural resource systems that threaten the ability of our institutions to cope. Fear of the unexpected (and, therefore, the unpredictable) dominates in our institutional systems since society (and her institutions) rewards success, not failure. However, failure in environmental management is not a rare event. Resource systems are complex and defy cogent predictability. The unexpected lies in wait for the best laid plans.

Fear of failure discourages identification and exploration of strategies and options, especially within middle level management, where an individual's career can be totally destroyed by a perceived failure. Consequently, the concepts of adaptability in management and learning from failure, when discussed with management, have generated very strong bureaucratic survival reactions. Management is threatened, and in consequence, often rejects the ideas (see References 8 and 14).

Thus, the problem becomes one of how to improve people's understanding of success and failure at the various organizational levels. Each action generating an observable outcome should be regarded as an experiment which provides an opportunity to learn more about the system being impacted. An unexpected result underscores our recognition that we do not have complete understanding.

Overcoming the Inertia

Certainly, it must be admitted that the practitioners of AEAM have been naive in their understanding of institutions and how they work. In the past, their institutional models were personal and ad hoc. In previous attempts to reach the decision makers, they went to the organizational level that appeared most receptive without reference to an overall strategy. Part of the problem here is that frequently the practitioners of AEAM are outside the organizations they are trying to affect, often as a consequence of the multi-institutional character of most resource management problems. However, the major stumbling block is ignorance of how institutions and their workers (i.e., the institutions' life blood) operate. If institutions functioned like a machine where everyone played a specific role and carried out his predefined function, then the appropriate decision level would be evident. However, such a structure would be a barrier to innovation. A more workable model is that institutions (and decisions) are effectively controlled by key individuals within an organization almost irrespective of their position. It is these key people who provide the mechanisms for innovation. The problem is how to recognize the key people and how to reach them. Without their support and commitment at the various strategic levels within an organization, failure becomes the most likely outcome.

Over the last decade, a number of critical lessons have been learned by the practitioners of AEAM regarding institutions and their response to the availability of a new technology (8, 13, 14, 15, 16). Certainly, the threat of many of these lessons is not new and has been the subject of numerous papers in the areas of organizational behavior, business science, and policy analysis (7, 19). Despite the existing literature, these lessons are presented here for two reasons. First, as mentioned earlier, naivete in this area is not unique to the practitioners of AEAM. Undoubtedly, there are others still struggling to get the "machine" to move faster. Second, the issues brought out by these lessons are still there after years of research and discussion, and bear repeating here.

- Implementation of analysis must begin at the initiation of a project.

- Implementation should focus on the people involved, rather than on the information or technology. Resistance to change is a very real problem and must be recognized as a formidable obstacle, especially if a large group is affected.

- Generally, the greater the difference between present and proposed tactics, the more difficult implementation is and the more likely is failure.

- New ideas have a definite gestation period that requires nurturing. Implementation, therefore, should be phased over time, providing time for ideas to develop, and for interpersonal and interinstitutional adjustment to occur.

- Evaluation and analysis must be requested by the individuals who have the power to use the results.

- Techniques of analysis must be understandable, transparent, and defensible against technical criticism.

4. PEOPLE

An Invaluable Resource

In Chapter 2, the lack of policy people and lack of a "wise person" were identified as reasons for failure in some AEAM applications. As stated earlier, the main ingredient in applying the procedures of AEAM is people; ideally people who have relevant expertise, innovative ideas, and personal initiative. Experience has shown that it is effectively impossible to involve all the people really needed for a collaborative effort. Invariably, conditions cannot be established that include all interested parties. However, it is important to be experimental in choosing who will be involved. Trying to second guess who will or will not be appropriate does not appear to work. There are numerous examples of the obstructionists transforming into involved participants and very dedicated supporters of the process.

RESEARCH SCIENTISTS

One critical participant subgroup is the research scientists. They bring expertise in how the biophysical and social processes of the world work and help identify the kinds and priorities of research needed to answer the questions raised in the modelling process. (It has also been said they keep the managers honest.) However, a troublesome issue here is how are research or information needs actually satisfied? Who, in reality, dictates research; the organization making the request, peer coercion, or the individual researcher? Since modelling and disciplinary paradigms often do not map cleanly, researchers may subvert the research effort to fit their own needs and interest. Without specific terms of reference to synthesize and control individual efforts from an assortment of organizations, the progress of any project, whether or not it is using AEAM, can be severely frustrated.

MANAGERS AND DECISION MAKERS

The other equally important subgroup includes the managers and the decision makers. They not only help keep research relevant, but also help chart a course through the morass of institutional machinery thereby, in theory, increasing the changes of the process and products influencing decisions. Knowledge of the historical pattern of decision making, outcome, and point of entry should eliminate many of the transfer and implementation options but is not a guarantee of success. The very fact that society's institutions (within which the managers and decision makers must operate) stress routine and minicry of procedure does not make the transfer from analysis to insight to action any less

nebulous and unpredictable. In the end, it gets back to the quality of the participants; their creativity, professionalism, and vision.

"WISE PERSON"

Related to the quality of participants is the need within any project for at least one "wise person"; an individual with professional understanding who has an intuitive knowledge that the process will help and knows the institutional environment well enough to nurse the process through to completion. Past experience would indicate that he need not be in a position of obvious authority, but he must have the respect and credibility of other institutional players. The difficulty is in recognizing the wise person. Does it take one wise person to recognize another? Sometimes the initiator in applying the AEAM process turns out to be the wise person; often not. It is clear that his existence is a necessary condition for ultimate success (8). Keen (7) also calls for the identification of a wise person (or as he calls them, "senior level fixers") in his recommended strategy for implementation:

"A senior level fixer must head the information function; he or she must have full authority and resources to negotiate with or between users and with those affected by information systems."

Muth and Hendee (19), on the other hand, divided the people in a social system into five categories:

- *innovators* — venturesome individuals who communicate outside the local system with a broader, more cosmopolitan system. They are usually characterized by their risky, daring decisions, not all of which are successful.

- *early adopters* — respected individuals who are well-integrated into the local social system. They have a high degree of credibility (i.e., opinion leaders).

- *early majority* — people who accept and implement innovations just a little earlier than the average adopters

- *late majority* — skeptics who view new ideas with extreme caution

- *laggards* — traditional workers who always reference the past and are usually one step behind the latest innovations

From the perspective of AEAM, the wise person falls into the early adopters category. Whereas innovators may be considered crackpots by local peers, early adopters are sought for advice and information. They are respected by their peers, in part, for the successful use of new practices. They have a knack for choosing that which works.

PRACTITIONERS

In the current structure of AEAM, the practitioners have a number of roles they must play within the process. Not only are they modellers, but they are also intellectual leaders, information critics, and professional facilitiators. Although each AEAM application requires a variation in emphasis of these roles (dependent primarily on the quality of the participants), it appears that each practitioner must have the diverse talents required for these roles.

Until recently, there were three experiments in the housing of practitioner expertise; that is, within a university (Institute of Animal Resource Ecology, University of British Columbia), a single purpose government agency (U.S. Fish and Wildlife Service), and a private consulting firm (ESSA-Environmental and Social Systems Analysis Ltd.). Each experiment has had practical and strategic advantages and disadvantages (some real and some imaginary) which have affected both development and execution of AEAM projects. For example, the university team has the advantage of relative institutional and financial independence of the user. They can afford to experiment and accept the risk of failure. Failure within the university environment is viewed as enlightening and presents opportunities for growth and learning. However, this experimentation has been regarded with extreme scepticism by outside organizations who discount new ideas emerging from the "ivory tower" intellectuals.

On the other hand, a private consulting firm cannot really afford to fail. Users are not very forgiving of dollars spent on perceived failures. Since the survival of a private firm depends on its ability to sell its expertise and maintain a viable level of cash flow, many of its applications have focused on those aspects of the process with immediate and tangible results (i.e., modelling workshops). So far, this experiment has not yet destroyed the experimenters.

The third experiment is the U.S. Fish and Wildlife experience. During its formative years, this team had the advantages of a large support system and was viewed as a practical, realistic group of concerned scientists representing the interests of government (and presumably, the public). Although sometimes viewed as partisan to U.S. Fish and Wildlife interests (and therefore, anti-development), this group has executed a number of exciting applications of the process. Unfortunately, recent cutbacks in U.S. federal government spending have resulted in this group losing its direct financial support from the U.S. Fish and Wildlife Service and has forced them to operate essentially like a consulting group (i.e., the users must pay a fee equivalent in amount to a consulting fee). On the other hand, they still operate within the structure of the federal service.

The primary question that these experiments raise is who should support an AEAM team? What institutional structure would maximize the team's impact on current decision making practices? One suggestion was the establishment of a neutral non-profit organization with no direct affiliation to any public or private organization and with access to support funds independent of its projects.

Another possibility is a team composed of members from a number of agencies that could convene for AEAM projects of mutual interest to their home institutions. This is currently being tried by the Great Lakes Fishery Commission and the Mekong Secretariat in Thailand (see Project Summaries, Appendix II). Although there appear to be constraints to team coordination, it is much too early to evaluate their effectiveness. Certainly, these two applications do indicate success in training practitioners within existing organizations.

PUBLIC

The AEAM approach, in principle, would seem to be amenable to public participation. The fact that the process stresses transparency (i.e., what is included and excluded is visible) and leads to the formulation of alternate (and hopefully creative) options does provide the public with information that, under traditional procedures, is not usually available. Certainly, if AEAM is to succeed in becoming a viable and trusted approach to resource management issues, it must involve the public in both the analysis and the evaluation. The question is how? Modelling workshops have very definite size limits that severely restrict the number of public representatives. Also, the confrontive style of interaction commonly practiced in North America between public and proponent would not be appropriate in a modelling workshop. If representatives of the public can be found who wish to contribute and work, then there is no reason why the public could not be an integral part of the analysis along with scientists and managers.

Perhaps, the reason that practitioners and users of AEAM are reluctant to have public interest groups attend AEAM exercises is a stereotyped image of these individuals as stubborn, uncompromising, and irrationally committed to biased and extreme points of view. No doubt many interest groups fall into that characterization. However, an examination of past AEAM experiences that have had public participation (Table 4) shows a surprising number of examples with a greater number of successes than failures.

The need for public involvement in environmental and resource management is an important issue still begging for a satisfactory solution. The ideas and procedures of AEAM are not incompatible with that need. Certainly, the experience summarized in Table 4 is encouraging.

TABLE 4.
AEAM applications with public involvement.

Case Study	Types of Public Participants	Level and Quality of Contribution
Jackson Hole	— Chamber of Commerce — Jackson Hole Alliance — Town Council member — Town Administrator — Ranch Owner	— good; carried most of the discussion
North Dakota Wetlands	— North Dakota Stockmen's Association — North Dakota Water Users — National Wildlife Federation — State Farm Bureau	— excellent; all the creative options came from one member of this group
Beluga Coal	— Native Village representative — Borough representatives	— fair; tended to sit back, listen, and evaluate discussions
West Coast Fisheries	— Commercial Fisherman Association	— successful in educating them about difficulties of fisheries management
Obergurgl	— Local farmers — Hoteliers	— excellent; the entire group reached a series of agreements on the issues facing the town
Mobile Bay	— Chamber of Commerce — Mayor of a suburb of Mobile — Audubon Society	
Sacramento-San Joaquin	— Audubon Society — Yachting Association — League of Women Voters — Representatives from Water Users Association	

What is needed is a structure that ensures public involvement is the norm rather than the exception. In any case, if trial solutions are not attempted, the utility of any analytic procedure, be it AEAM or not, to the decision maker will be diminished and will risk an ever increasing number of failures.

COUNTERIMPLEMENTERS

No discussion of the people within the AEAM process would be complete without mention of the counterimplementers: the surprisingly powerful and omnipresent individuals who resist the process. These people are not necessarily "evil", since many of the ideas they challenge are poor ideas to begin with. However, some innovations do threaten the interests of individuals and groups by intruding on their territory, limiting their autonomy, reducing their influence, or adding to their workload. Obviously, there is a qualitative difference between honest resistance to a project one feels is misguided, and selfish sabotage of a necessary innovation. In the first case, clear and open communication

usually liquidates the issue; in the second case, a series of countermoves is required. Both Holling (8) and Keen (7) see the strategy of this group in the context of a game that requires a suitable counterstrategy.

For example, Keen recommends:

- make sure you have a contract
- seek out resistance and treat it as a signal to be responded to
- rely on face to face contacts
- become an insider and work hard to build personal credibility
- co-opt users (and supporters) early

Generally, we have found the procedures inherent in AEAM promote these strategies and are effective at neutralizing much of the counterimplementation activity. However, the reality of the situation is that these people do exist and must be dealt with.

5. PRODUCT AND PROCESS

In Chapter 2, the users and practitioners identified inadequacies in the simulation model, available data, and application planning as major reasons for failure in some AEAM applications. From the perspective of this review, these concerns are related to the products of AEAM and the process and procedures of application. The question is, what happens between proposal and implementation?

In the past, AEAM has been sold as appropriate to everyone. Inherent in this is the assumption that the user wants what the process provides. However, there is a need to package the process and its products to suit the requirements of each application. In order to do this there must be a perception of what is wanted and needed in each situation. Further, there must be consideration of what attributes of the products are important, how the product is sold and presented, and how to enroll all those people who are important for addressing the problem at hand.

Product Attributes

AEAM is not the first innovation which has experienced difficulties in implementation. In fact, thousands of studies in the social sciences have been devoted to the adoption of innovations. Muth and Hendee (19) summarize the characteristics of any innovation which influence its rate of implementation:

- *Relative advantage* is the degree to which an innovation is more beneficial than the tool, method, or idea it replaces. Relative advantage is usually judged in economic terms (increased yields from hybrid corn) but may also be measured in any other terms which reflect values and objectives (e.g., quality of public service).

- *Complexity* is the relative ease with which an innovation can be understood and implemented. The electronic calculator, for example, is extremely simple to use, and it is being adopted at a phenomenal rate.

- *Trialability* is the extent to which an innovation can be implemented a little at a time. No manager wants to risk too much on a new, untested approach. If the approach will work on a small scale, such as a few acres of hybrid corn, then it is more likely to be tested and adopted.

- *Compatibility* is the degree to which an innovation is consistent with the attitudes, values, beliefs, and needs of potential adopters. For example, it is difficult to adopt a policy of letting wildfires burn in wilderness areas; the policy conflicts with traditional views.

- *Observability* is the ease with which an innovation or its effect can be seen. Tangible products, such as television sets, can be judged more readily than intangible ones, such as increased communication. Delays between experiment and result (such as those inherent in silvicultural practices) also constitute a serious handicap to adoption.

The Products of AEAM

The products of AEAM are both tangible and intangible. The tangible products take the form of computer models, reports, and presentation packages. The intangible products are related more to the process and are probably, in the long run, more important than the tangible ones. Criteria for adoption determine that these products will be implemented at different rates; and it is useful to recognize what attributes could be enhanced to facilitate adoption.

COMPUTER MODELS

Over the last decade, we have seen the development of an overwhelming number of simulation models covering almost every issue imaginable. Although this kind of exposure helps remove some of the mystique of computer models, it has also generated an atmosphere of suspicion. As a consequence, many analysts try to deemphasize the predictive aspects of the model and, rather, stress the learning and communication that comes from building the model. Such a response is avoiding responsibility. Granted, a first AEAM workshop model may be too crude to serve as a predictive tool. But, that just points to the need for more analysis, simplification, and invalidation. The truth is a user does want prediction. What is important is that an appropriate level of salesmanship be executed to clarify the accuracy of the results and avoid their misuse. An explanation of the associated risks and uncertainties should be included with any model prediction to ensure the user has the appropriate perspective.

Users perceive predictability as the obvious relative advantage. The advantages of communications, interaction, gaming, and policy testing are not as well understood. For some time, computers were regarded as incompatible with human values, however, this prejudice is changing as computers are assimilated into the culture. A model can be used to aggregate complexity, but it can also be used to exaggerate it. Clearly, if

models are to be acceptable, simplification is a priority issue. In some respects, models are designed precisely for trialability; management actions can be tested on the model without producing irreversible effects. By specifying a range of scenarios to be applied to the model, a user can test extreme management alternatives. Through the iterative procedure of model refinement and evaluation, the user can eventually make recommendations on the quantity and quality of analysis required to further improve the model's (and, therefore, the user's) predictive capability.

A model can be made easily observable: nothing has more impact in a workshop than the visible results from a running model. Similarly, model content can be made very visible in the workshop process and in carefully designed presentations. There is clearly an attitude of acceptance when a model is successfully made observable. The availability of computer graphics and user-friendly computer software goes a long way towards promoting utility and user satisfaction in any modelling exercise. The ability to provide hands on gaming often results in large shifts in the impact a modelling effort can have on the decision process.

REPORTS AND PRESENTATION PACKAGES

In one sense, reports and presentation packages can be viewed as a communication of the real products; in another sense, they can be regarded as products in their own right.

Usually the success of the work is judged primarily on the content of the report. The advantage of the report is that it is a consensus document emerging out of the collective expertise of the participants involved in the process. It can enhance the credibility of the effort and provide the user with professional support. Reports are highly compatible with standard institutional procedures. However, there is variation between institutions, and it could be beneficial to tie the report writing more closely to user requirements. This could be done by including the user in report writing so that the product is appropriately tailored for its readership or audience.

Reports tend to be gloriously complex tomes with detailed descriptions of the model, scenarios, and a summary of workshop proceedings. As we have already discussed, acceptance is a function of simplicity; and simplicity required is a function of audience. If a detailed report is required, it should be accompanied by a series of shorter documents, such as carefully constructed abstracts and executive summaries. Although reports, per se, are readily observable, the benefits of the report are not clearly visible. The real value of the report to the user is usually not perceived when it is being written for the purpose of completing a contract. Reports could become a useful tool of AEAM if

the advantages of that tool to the client were clearly articulated.

Similarly, presentation packages can be designed either for the practitioner, to enhance his ability to describe the model or the procedure, or they can be designed to satisfy the needs of the user. The advantages of audio-visual communication packages is that they are the quickest method of informing people about the results of an AEAM application without the mind-numbing detail of a model or workshop minutiae. They are also surprisingly amenable to a wide variety of audiences from different disciplines, roles, and institutions.

Sensitivity in their design and presentation is required to ensure compatibility; some audiences are insulted by caricatures, whereas others do not absorb technical graphics. As with reports, the packages can be easily experimented with and are eminently visible, but their effects are very difficult to measure.

INTANGIBLE PRODUCTS

The intangible products include the development of a common understanding, increased communication, bridging of credibility gaps, and an appreciation for the strengths and weaknesses of the application. Furthermore, AEAM encourages changes in attitude which are reflected in management; namely an experimental adaptive approach which acknowledges uncertainty. Managers are not so much suffering from a lack of analytical tools as from a lack of understanding of the risks associated with management decisions. What AEAM attempts to do is clarify the risks and ensure that managers and decision makers appreciate we are always managing in an environment of the unexpected. It clarifies that success is not guaranteed and that we must design with this in mind.

A product often associated with AEAM is the generation of creative options. In fact, what AEAM does is to generate an environment in which creative options are more likely to emerge, and in many applications, this has been the result.

The relative advantages of these intangible products are particularly difficult to identify. Many of them are only perceived by those people who measure advantage in a broad context. The attitude changes inherent in the intangible products are, by definition, not compatible with current attitudes. However, acceptance of these concepts does simplify management; it generates a context which allows interpretation of pattern rather than detail. Attitude changes could be reasonably and easiy experimented with, but individuals tend to invest in their subscription to a set of attitudes. Finally, the intangible products are, by their nature, difficult to observe. According to the characteristics of

innovation previously defined, it is not surprising that these fundamental products are being accepted rather slowly.

The Process of Adoption

The rational and naive model of adoption of new ideas, methods, procedures, etc. is that you inform someone of how good the product is and they accept it. Many public information programs have generated entertainment value but no action. Similarly, academics are surprised when their useful innovations are not immediately adopted in the outside world.

Although terminology varies somewhat (19), social scientists recognize several stages between information and action (Figure 7). Before anyone will let awareness of a new idea penetrate, there has to be a condition of acceptance; that is, the individual should not feel the need to be defensive about his current ideas or practices. If the practitioner does not understand and accept the user, acceptance can be generated by communication. (Users cannot understand AEAM unless practitioners listen to them.)

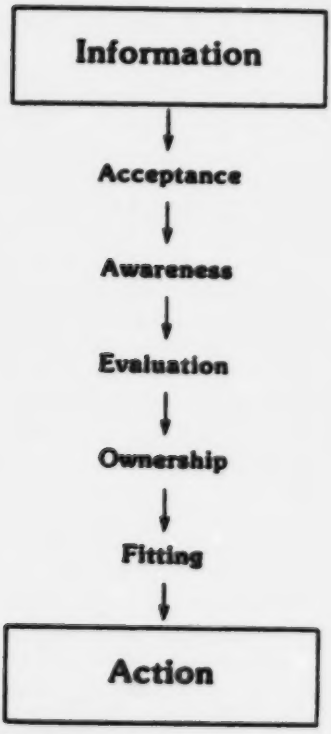


FIGURE 7.
Information alone does not guarantee action.

Awareness and interest often come first from exposure to mass media and conversations. The first thing an individual may encounter is the name "Adaptive Environmental Assessment and Management". There is an indication that this name is misleading. The word "environmental" appears to include only biophysical problems; furthermore, in some management groups, it has negative connotations. The phrase "environmental assessment" has many definitions and is, hence, confusing. Adaptive Management is given a specific definition in this review; no other alternate for AEAM has been proposed.

Interest often comes from contacts with other individuals or agencies who have had exposure to the process. Besides all the attributes of success and of products discussed elsewhere in this review, this brings

up the question of fulfilled expectations. In selling the approach, practitioners have often promised more than what was actually delivered. Users have often felt frustrated at the difference between promises and products even when they were pleased with what they did receive. This disparity does not enhance confidence in AEAM.

The stage of evaluation (Figure 7) commences with a mental application; a weighing of the pros and cons, the complexity, the trialability, and other considerations. In effect, the individual is asking "can I and should I?". Personal contacts and the advice of opinion makers is particularly important at this stage. The use of simulation models in AEAM caters to this stage as management and policy alternatives are easily evaluated. There is evidence (20) that workshop participants will not have any confidence in a model until they have had a chance to test their own projections. The evaluation stage may require some time; then, at some point, the individual goes through a subtle change and "owns" the idea or process. Two things should be clear about ownership. First, a successful application cannot be made until the user "owns" the idea; and second, once he makes this transition, he becomes responsible for the interpretation of the idea. Namely, the originator has no more control; it is no longer his idea.

Next, the new owner of the idea can talk about it, or he can complete the sequence and fit the idea to his requirements and actually implement it. There is no success until the action occurs, and this may take a long time, especially if the process must be experienced by many individuals in an institution. Here it is important to recognize that some people decide faster than others, and that an individual's behavior is influenced by his neighbor's.

Packaging

So far, insufficient attention has been devoted to packaging. What is required is an adaptive style of execution of AEAM, specifically designed to meet the needs of different projects and users.

AEAM practitioners have tended to push a standard workshop format upon a wide range of users, problems and institutional structures without much thought as to how the standard format could be modified to suit a particular set of circumstances. This has sometimes caused frustration for participants and perhaps hindered further use of AEAM in the project and implementation of workshop results. For example, users want something they can apply after the first workshop; not a momentary surge of enlightenment. To attain a product such as a working model, AEAM clearly needs to be packaged as a series of iterative workshops. Furthermore, the model needs to be designed in

such a manner that the user can continue working on it as more data and understanding become available.

The packaging issue evokes visions of better designed products (models, reports, and audio-visual presentations). In fact, the packaging issue is also concerned with the processes, in particular, with communication. Simple day to day conversations during the normal course of business have resulted in better acceptance of the recommendations and results of AEAM (for example, Obergurgl, the Ontario Ministry of Housing, and Beluga Coal). It may take a longer time for the successes to become apparent, but they may be more effective because of the person to person contacts.

Opportunities for presentation of AEAM to a larger audience are rarely predictable; they often come as complete surprises to AEAM practitioners or the user. Possible responses to these opportunities vary with the nature of the opportunity. For example, a simple briefing session may be sufficient for a policy advisor; a model gaming session may be required for a technical group within an agency.

A final packaging issue concerns the question of public involvement. Given that the desires and opinions of the public do influence decisions and their outcome, how can we affect public opinion? Can the process of AEAM be packaged to align a large public with the concepts of adaptive management? What is needed is new, innovative, and diverse approaches to the public that include intense compression and synthesis but still maintain the major ideas and transparency of the process. There have been a few isolated excursions into the public realm, the most notable of which are Obergurgl and the West Coast salmon management. In fact, the salmon management work is continuing and is currently going through a public inquiry with model presentations to large meetings.

6. CONCLUSIONS

In a report such as this, it is difficult to present conclusions without some redundancy. The previous sections and the appendices are a synthesis of many ideas and suggestions that were either expressed at the January workshop, gleaned from the literature, or taken from the authors' experience. Many ideas have been stated before, sometimes with different words, or in a slightly different context; other ideas have benefited from a gestation period and were expressed after some maturation. The practitioners have learned from their mistakes, and continue to do so. Although one would like to think that lessons learned eliminate the problems, the concerns brought up in the preceeding pages invalidate that hypothesis. Most of the problems are still there and are bound to remain so for the foreseeable future. However, these problems are being responded to by changes in the package and the product. By changing the style of presentation and implementation, it is hoped that future applications of AEAM can be executed in a safe-fail mode (8). Given the inevitable failure, it is critical to ensure the failure is not catastrophic. Success is too nebulous a concept, from the perspective of AEAM, to be guaranteed. Rather, an application must be structured to ensure the project survives and benefits from failures.

Suitable Applications for AEAM

As defined in the introduction, AEAM is a collection of concepts, techniques, and procedures for the design of creative and effective resource management and policy alternatives. Rarely can a particular application be formulated and implemented at a policy level primarily concerned with generating creative alternatives. Most applications are much more specific and narrowly designed. In particular, application types are often designated using names of standard elements within traditional management: research planning, impact assessment, synthesis, and management planning. One of the basic questions addressed by this review was: should AEAM be used for the above activities?

During the January workshop, discussions were focused on four areas of applications. These are presented in the appendices and summarized in Chapter 2 (pages 7 - 35). The overall feeling was that AEAM does fit into each application in various ways at various stages. Not all applications have equal exposure. Research planning is fairly well-tested, whereas impact assessment has not really been tried.

In one sense, these application types are theoretical. The practitioner and user evaluations did not identify past applications as belonging solely to any of the above types; rather each was unique in its mix of

objectives. Application types can be similarly characterized by the mix of objectives they incorporate, either explicitly or implicitly. For example, the application, "Environmental Impact Assessment" (EIA) does not only have as an objective the identification of impacts, but, in order to be successful, it must also identify issues and unknowns, synthesize information, achieve communications, and in many cases, plan research (Table 5). The recommended approach for evaluating AEAM for a new application is to identify the objectives to be met, and to evaluate the suitability of AEAM for those objectives. This method provides a more rational decision mechanism than blanket appraisals for application types.

APPLICATION / OBJECTIVE	Environmental Impact Assessment	Research Planning	Resource Management and Policy	Integration and Synthesis
Identify Issues and Unknowns	●	●	●	○
Identify Impacts	●		○	
Communication	○	○	○	○
Information Synthesis	○	○		●
Research Planning	○	●		
Policy Analysis			●	
Project Management	○	○		

● primary ○ secondary

TABLE 5.
Objectives inherent in the four identified application types.

Elements for an AEAM Package

It is sometimes difficult to decide which of AEAM's procedures and techniques should be included in a given application. Each of the application types discussed in the report have a set of objectives inherent to them (Table 5). In most cases, there is one or more primary objectives and secondary objectives associated with each application. For example, an application of AEAM to environmental impact assessment has primary objectives: identification of issues and unknowns and identification of impacts; with secondary objectives: communication, information synthesis, and research planning.

Deciding which techniques to use for a given application becomes clearer if the techniques are linked with the objectives (Table 6). Some tools are essential to achieving success in a given objective; others are optional in the sense that they enhance the likelihood of success or improve the quality of the product. Almost all of the objectives require a structured workshop and may require some modelling. Often these are combined in simulation modelling workshops.

● essential
○ optional

	COMMUNICATION					ANALYSIS			
OBJECTIVES	personal contact	structured workshop	report	presentation package	series of workshops	model building	gaming	data analysis	simplification
Identify Issues and Unknowns	●	●	●	○	○	○	○	○	○
Identify Impacts	●	●	○	○	●	●	●	●	○
Communication	●	●	○	●	●	○	●	○	●
Information Synthesis	●	●	●	○	●	●	○	●	○
Research Planning	●	●	●	○	●	●	○	●	○
Policy Analysis	●	○	○	●	○	●	●	○	●
Project Management	●	●	●	○	●	○	○	○	○

TABLE 6.
Elements of AEAM recommended for achieving success in each objective.

Other factors, besides the objectives of the application, may determine the appropriateness of a particular tool. These are people, institutional issues, budgets, and time constraints. The selection of the tools for a particular application remains a choice based on the collective wisdom, experience, and intuition of both user and practitioner.

Summary of Major Issues

To serve as a framework for a final summary, a series of hypotheses has been structured appropriate to this review process. The hypotheses are posed in the positive sense. If future applications cannot disprove these hypotheses, they are likely true. Although not testable in the true scientific sense, the hypotheses serve as a focus for the major issues relevant to AEAM.

SUCCESS IS PREDICTABLE

Certainly success is an elusive quality that is difficult to measure. Although criteria may be defined, no clear metric is available. Opinion, however, is the operational measure as far as credibility and use of the techniques goes. User opinion is, on the whole, favorable, especially when longer term effects are considered. Invariably, success in any application is a composite measure of success in numerous objectives.

It may be that the success or failure of AEAM depends partly on the scale of the problems and issues being addressed. AEAM applied to specific, narrowly focused management problems may have a greater chance of failure because many of the possible sources of surprise lie outside the system being considered. These sources of surprise may not intrude on the specific system if it is isolated or if the timescale is so short that the outside system is not likely to change. On the other hand, broad policy problems viewed over a longer timescale may have a good chance of success because the possible sources of surprise will tend to be within the system being considered and will therefore be acknowledged as such.

AEAM IS USEFUL

Decisions are made by decision makers and as Keen (7) so eloquently points out, decision makers still prefer simple, proven, experiential, and non-analytic procedures to help them in their decision. Formal analysis is often viewed by decision makers as an intrusion and criticism of their capabilities, therefore, they ignore the analysis.

Inevitably, the ability to impact decisions comes down to the people and the packaging of the process and product. Practitioners are rarely in a position to influence decision makers directly. What the practi-

tioner can do, especially in partnership with a "wise person", is facilitate interaction and communication between different roles (e.g., scientist, policy advisor, public) and between institutions concerned with policy development. He can provide tools which allow all the roles to evaluate policy options in a framework relevant to their needs and interest. In this procedure, the practitioner functions as an independent third party to policy information.

AEAM includes not only the tools for policy evaluation but also the philosophy of adaptive management. Tools are easily accepted from a third party, but a philosophy must be experientially learned and internalized. AEAM practitioners, by conducting a few workshops, cannot hope to change the management philosophy of an institution. The practice of AEAM within various departments of a management agency can certainly help to break down traditional management and policy design processes and replace them with design processes which explicitly acknowledge risk and uncertainty and are, therefore, adaptive. AEAM practitioners can be used as instruments of change; they cannot be the source of change.

PEOPLE ARE IMPORTANT

Probably the most pressing issue brought out in the preceding pages is the need to get a better understanding of people; how the behave, why they do what they do, and how they make decisions. Certainly, the common theme in most AEAM applications so far, from one perspective or another, is people, and not the support technologies. Society does not need bigger computers or computer programs to carry out better resource analysis. Instead, what is needed is a better understanding of how people and their institutions operate. It is not always necessary to spend millions of dollars getting more data and building bigger models before making a decision. But, it is necessary to learn how to tailor the analyses and models to better serve people. Decision makers need to learn how to deal with the unexpected so they can make pressing decisions now and use the outcome of those decisions to help monitor, evaluate, and adapt in the future.

THE RIGHT PEOPLE CAN BE INVOLVED

This gets back to the issue of people and their importance. Since certain people are important in an AEAM application, the success of the endeavor is going to be highly dependent on getting those right people.

Generally, we have found that once the right people are located, they invariably want to be involved (maybe that is what makes them right). The problems are finding them and then getting access to their time (i.e., will their home institution let them participate). Often, innovative and creative people have a knack for keeping their ear to the ground

and picking up the "vibrations" of a new activity. However, this is more common with research scientists than some managers. Decision makers are usually too busy (or threatened) to enable them to make a full commitment. Definitely, they are important and should be somehow involved. This gets back to the notion of packaging. There is a definite need to develop different packaging styles that cater to the requirements of the range of users that AEAM attempts to involve. Some suggestions have been made and will be tested.

AEAM IS COMPATIBLE WITH CURRENT INSTITUTIONAL ENVIRONMENTS

One of the major issues discussed at the January workshop was the problem of dealing with the institutional environment within which most resource problems must be solved. Ultimately, this comes down to what we termed institutional inertia in Chapter 3; the apparent inability of institutions to adapt to change. Obviously, institutions do adapt (they must to survive); but they do so much more slowly than society's problems develop. This is primarily a function of the "future shock" phenomena in which our external environment (and, therefore, our interactions with it) is changing much faster than our ability to cope. Traditionally, institutions have changed incrementally; large steps are avoided except in crisis. Public policy problems tend to be much too messy and ill-defined to be amenable to anything but a partial analysis, and, therefore, institutions are not willing to risk anything more than a small change. This implies that visible changes in response to incremental shifts in policy will occur on timescales of one or two decades; not one or two years. What AEAM can do is to create a context which makes adaptation and change more feasible for institutions.

A key point that has become clear in past applications of AEAM is that implementation is very much a political process. When that is accepted, then the organizational mechanisms follow naturally. As long as we do not equate politics with evil, corruption, and non-rationality, but rather as the process of getting commitment and support, then institutions present no greater a hurdle for AEAM than for any other innovation.

AEAM IS COST EFFECTIVE

The cost effectiveness of an AEAM application is difficult to measure (as it is with any method) since it is difficult to determine the cost of mistakes not made or unnecessary dollars not spent. On the other hand, application costs of an AEAM style approach can be measured. Facilitators, participants, computers, reports, etc., do cost money and it is measurable. Some have complained that AEAM is expensive, especially the up front costs for the initial phases. When people feel the status quo works it is sometimes hard to rationalize the expense. In

reality, the status quo does not work; all it does is succeed in satisfying the morass of legislation that attempts to control and mitigate development. Although admirable in attempt, the current procedures for managing and protecting our resources fall far short of societal requirements.

A Final Word

Gordian Knot: a knot tied by Gordius, King of Phrygia, held to be capable of being untied only by the future ruler of Asia, and cut by Alexander the Great with his sword.

— Webster's Dictionary

AEAM cannot cut the Gordian knot of environmental management; but it can begin to untie it. The key to AEAM's future success will be in its ability to adapt to uncertainty. Many of its procedures and techniques will evolve and change. The less successful must be culled and the more successful improved upon.

In the previous chapters, many issues were raised, but few solutions offered. All of these unresolved issues relate in one way or another to the theme of uncertainty. Because uncertainty is real, these issues will always need continual attention, and we cannot predict the future evolution of AEAM. There is little doubt that it will survive in some format; the exact format is unclear. In truth, no methodology can overcome all these issues, however by being adaptive it can deal with them.

To some extent, lessons learned from past applications, and conclusions drawn from the responses of affected biophysical and institutional systems, provide a guide for future applications of AEAM. However, each application creates a new system and its nature cannot be predicted only through observation of past case histories. Therefore, throughout all stages of an application, AEAM must be adaptive both in style and content. AEAM's procedures are part of an ongoing investigative process that attempts to deal with uncertainty by adapting to new situations as they arise.

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APPENDIX 1

Major Areas of Application

As mentioned in the introduction, in January, 1982, a three day workshop was held in Parksville to review and evaluate the AEAM process. As part of that workshop, four broad areas of potential application were identified:

- Environmental Impact Assessment
- Research Planning
- Resource Management and Policy
- Project Integration and Synthesis

On the second day, four participant subgroups were identified and each was assigned the task of evaluating the utility of AEAM within one of the application areas. The results of those discussions are presented in this appendix.

In preparing these summaries, we have tried to remain as true as possible to our records of those meetings. As a consequence, there is some difference in presentation styles. Also, frequently the ideas and issues discussed repeat some of the material found in the main text of this report. We decided to maintain this redundancy, primarily so each application section could effectively serve as a stand alone document.

Environmental Impact Assessment

1. *Brief History* (in North America)

In Canada, the EIA process (from a federal perspective) finds its home within the Environmental Assessment Review Process (EARP), established by Cabinet in 1973 and amended in 1977. EARP was established as a means of determining in advance the potential environmental impact of all federal projects, programs and activities. "Federal projects are considered to be those initiated by federal departments and agencies, those for which federal funds are solicited and those involving federal property. This includes projects that may originate outside the federal government, but involve a particular federal department through funding or property considerations." (Government of Canada, 1979). It should be noted that projects not included in this definition are not subject to any federally legislated environmental review

process but usually have to meet some other licensing requirements (e.g., federal or provincial) that often have an EIA style procedure (for example, the B.C. Utilities Commission Act for the regulation of public utilities in the province of British Columbia).

In the United States, the EIA process, from a national perspective, is couched within the National Environmental Policy Act (NEPA) which was passed by Congress in 1969. In 1978, recognizing the multitude of problems with how NEPA was eventually implemented, the Council on Environmental Quality (CEQ) issued regulations for implementing the procedural provisions of NEPA. The intent of these regulations was to reduce the paperwork and accumulation of extraneous background data, so as to emphasize environmental issues and alternatives and try to make the NEPA process more useful to decision makers and the public.

2. *The EIA Process*

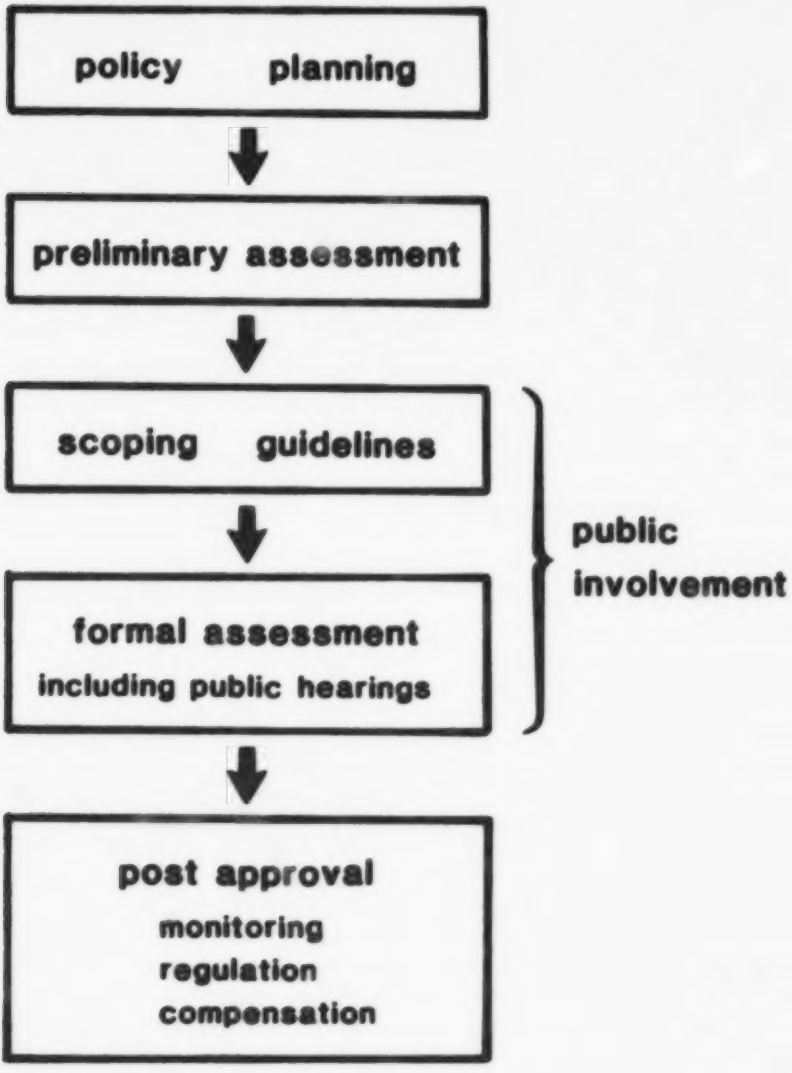
For the group's discussions, a generalized model was agreed upon which captures the major phases of the EIA process, as practiced in both Canada and the United States (Figure A.1). Briefly, these stages were defined as follows:

(a) *Policy/Planning*
The policy/planning stage is the first step after initial interest is expressed in a particular project or development scheme. Usually the objectives and design of the project are conceptual and still capable of responding to extreme shifts in policy and priority. The objectives of this stage are to:
1) identify information gaps and uncertainties;
2) predict possible outcomes (i.e., impacts);
3) identify the relevant issues; and
4) obtain an integrated picture of the system and a synthesis of ideas.

The major products are:
1) a range of options;
2) a problem analysis that has considered all reasonable alternatives; and
3) a recommended strategy for proceeding or cancellation.

(b) *Preliminary Assessment*
This was viewed as an interactive stage following policy approval. It is very much still a screening exercise that evaluates the alternatives to project design and implementation. The objectives are not oriented toward a legal document or a public hearing but rather a

FIGURE A.1.
Generalized model of EIA process common to the United States and Canada.



more definitive study of the major issues and a thorough ecological synthesis utilizing existing information. The product is a preliminary Environmental Impact Statement (EIS) that describes the rationale behind what should be included and excluded.

(c) *Scoping/Guidelines*
This is an extension of the Preliminary Assessment stage that incorporates public participation and reviews the range of actions, alternatives, and impacts to be covered in the final EIS. In Canada, the major product is a set of guidelines established by a review panel for the proponent.

(d) *Formal Assessment*
This is the rigorous assessment stage occurring over one to a number of years. It usually involves new research activity, data collection, public hearings, and impact predictions. At this stage, the project is fairly specific in design and objective. The end product is the final EIS and a review board decision on how the proponent should proceed.

(e) *Post Approval*
Given a go ahead decision after the final EIS, the post approval process involves:
1) the design and implementation of a monitoring program;
2) implementation of any required mitigation and/or compensation activities; and
3) enforcement of regulations.

Basically, the post project stage provides an evaluation and validation of the effects of the activity.

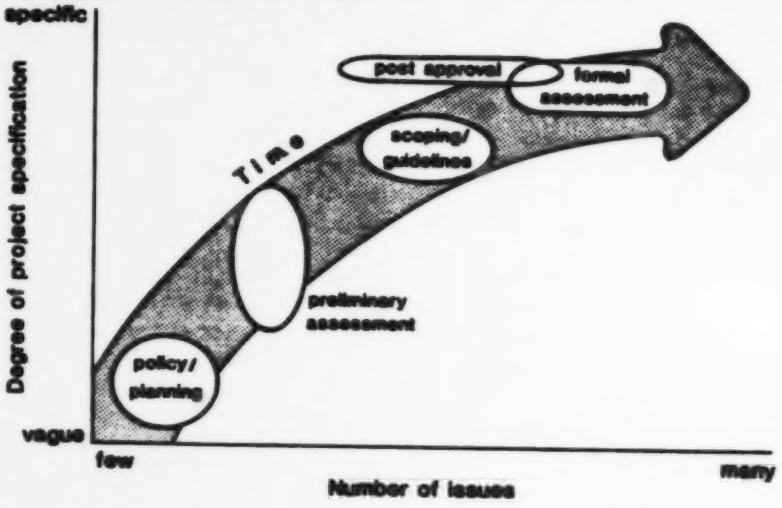
It is interesting to note that the further you proceed into the EIA process on the one hand, the greater the number of issues (and interest groups) that must be included in the analysis, while on the other hand, the project, which starts out relatively vague and ill-defined, becomes more and more specific and narrow in design and function (Figure A.2).

3. *AEAM in the EIA Process*

Throughout this subgroup's meeting there were two major biases that set the flavor of the discussions and eventual recommendations:

(a) EIA should be a learning process for both the proponent and convener and not approached as purely a legal hurdle to project approval. To ensure rational and reasonable environmental management, the proponents must understand what they have to do and why. Similarly, the convener must take a more active role in identifying the environmental needs and impacts of a project, a responsibility currently with the proponent.

FIGURE A.2.
As you proceed in EIA process on the one hand, the number of issues that must be considered increases, while on the other hand, the project becomes more specific in design and intent.



(b) AEAM has great potential to contribute to the EIA process. AEAM is a procedure that stresses many of the criteria identified as necessary in the execution of an effective EIA (i.e., workshops, predictive models, quantitative assessment, collaboration, adaptive strategies, communication, project synthesis, and continuity).

Given the many frustrations and shortcomings that have been raised about the current EIA procedures, especially in the United States, the group did not feel these biases were unreasonable. (The reader is directed to Schindler (1976), Fritz et al. (1979), and Watt (1977) for a discussion of the "impact statement boondoggle" as Schindler so aptly puts it.)

Therefore, in response to the question "is AEAM appropriate to EIA?", the group's immediate answer was "yes!", and a new question was posed: "at which stages is AEAM appropriate and how?". The answer to this question makes up the remainder of this section.

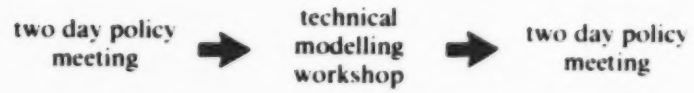
Policy/Planning

The consensus of the subgroup was that modelling workshops would be very appropriate at this stage. The whole thrust of this first step in an EIA is focused on evaluating options and identifying uncertainties, the key benefits of modelling workshops. At this stage, the workshop would be very much an internal procedure (in government or industry)

used to establish a congenial atmosphere for brainstorming. The participants should represent the complete range of disciplines relevant to the project/program and available *within* the convening organization. The user, in this exercise, would be senior decision makers or advisors who wish to structure and evaluate and complete set of options and then develop a recommended strategy.

What is unique about using modelling procedures at this stage is that it allows the user to integrate information, pose various scenarios, and answer "what if" questions with complete knowledge of the constraints and high profile issues. The gaming aspects of the model building also provide a powerful tool for evaluating system sensitivities, improving institutional understanding of future needs, and for enhancing internal communications.

Generally, it was felt the policy/planning stage would have to generate a recommendation within 3 to 6 months to be useful to an organization. One possible sequencing of the workshop procedures is:



The initial two day meeting would involve senior management/policy people and would attempt to define the major issues and bound the problem. The technical modelling workshop would involve the technical/scientific expertise (internal to the organization) who would build an interactive dynamic simulation model within the bounds identified at the policy meeting. The final two day policy meeting would focus on refining the key issues and uncertainties in light of what was learned by building and gaming with the model.

Preliminary Assessment

Application of AEAM to Preliminary Assessment would again be an internal process that would involve in-house expertise, outside consultants and possibly, some review agencies. The objectives would be further refinement of the key issues, an ecological synthesis, and a clarification of what is relevant and irrelevant.

This stage should take no more than six months and would best focus on two workshops with an intervening consolidation period. The first workshop would approach the problem from a more intense technical modelling level and more clearly define the key issues and information

needs. During the intervening period available information would be collected, analyzed and used to parameterize and calibrate the model. The second workshop would focus on gaming with the model to establish priorities in information needs and some preliminary predictions of project impacts. The benefits of using the workshop approach in this context are:

- the key issues are identified
- the analysis is broad in scope and the multi-disciplinary questions are well integrated into the analysis
- the workshop procedure fits well institutionally
- the workshop procedures can adapt and assimilate new information as it becomes available. Therefore, the model and analysis provide continuity on to the following stages.

It was felt by the subgroup that if a good preliminary EIS is structured at this stage, the final EIS will be of a much better quality. It is crucial at this stage to establish credible criteria for screening the options and a defensible rationale for what is excluded from the analysis.

There are some risks associated with applying modelling workshops at this stage.

- Data needs that were given a low priority and therefore ignored may be later identified by a review panel as critical.
- The process may identify a previous non-issue as a critical issue that could result in unexpected high mitigation/compensation costs to the proponent.
- Workshops/AEAM are unproven in the context of EIA and have uncertain value.
- The emphasis on simplification could result in elimination of a key issue that may emerge later in the process.

Scoping/Guidelines

From the perspective of applying AEAM, this stage is really a continuation of the preliminary assessment stage, only now the public is involved. The major objective is to establish communications with the public and other interest groups and identify the key system indicators.

The client in Canada is the review panel; in the United States, it would be the proponent. The product is a set of guidelines to be followed by the proponent in preparing the EIS.

Again, the workshop procedure is appropriate here although, as mentioned earlier in this report, it is not clear how to effectively involve the public in the model building process. Since any interested party can become involved at this stage, what may be appropriate is a collection of workshops at different locations within the impacted region. If an appropriate style could be developed to involve the public, there would be many benefits. These would include:

- better communication between proponent and public
- continued interaction between all interested parties thereby helping to diminish cross interest suspicions and confrontive strategies
- an integrated analysis
- a collaborative identification of issues that could be iteratively refined through a sequence of workshops/meetings

The main problem with a workshop style procedure at this stage, from the perspective of the proponent, is the issue of transparency. Given all the issues are identified and clearly defined to the public, a failure to solve a key negative impact could result in strong opposition to the project. Also, since it is not known how the series of public meetings would be carried out, the resultant costs and timing may be excessive.

Formal Assessment

The formal assessment is the longest part of the EIA process often taking a number of years. The client for AEAM at this stage would be the proponent who would use the traditional workshop-consolidation-workshop sequence over the full period primarily as a research planning/coordination tool, (see Research Planning section in this Appendix). The eventual product would be the final EIS.

Although modelling workshops have not been used explicitly in the preparation of an EIS, they have been used extensively for research planning. To ensure successful application of the workshop/systems analysis process within the formal assessment, there is a need for continuity of process from start to finish. This would require the establishment of a board or committee that would have the directive to remain intact for the duration of the analysis and facilitate the final

reviews (for example, the EARP panel). The major benefits to the proponent of using AEAM at this stage are:

- a better integrated product
- coordination of effort and evaluation
- a better understanding of the system dynamics allowing analysis to be more prescriptive than descriptive
- alternative strategies can be analyzed quickly
- information needs can be prioritized and rationalized
- modelling workshops are suitable forums for educating and establishing critical communication links

Some of the drawbacks are:

- as before, the analysis forces simplification. An issue left out of the analysis may, at a later date, (but prior to project approval) become critical.
- much of the resultant analysis and modelling is dependent on the quality of available participants. Considerable effort must be expended to ensure the participants are the best available.
- the success of the workshop/AEAM process within the preparation of an EIS is, to date, unproven (except from a research planning point of view).

Monitoring and Regulation

The subgroup felt that the full AEAM process is very well suited to this stage of the EIA process especially in evaluating the effects on unregulated issues (for example, socio-economic issues). In the past, there has been no rational approach to developing appropriate mitigation and/or compensation strategies for most of the biological and socio-economic impacts of development. AEAM provides a very innovative methodology for rationalizing this process and helping to solve these problems collaboratively. It was felt that the workshop procedures could be easily adapted to work in a conflict resolution mode in a style similar to that discussed in Straus and Clark (1980). At this stage of the EIA, the client for AEAM could be almost anybody who wishes to design a post audit procedure to evaluate or regulate the effects of the project.

Certainly, from the point of view of the proponent, the analysis and model emerging out of the final EIS would provide an ideal structure for designing and maintaining a monitoring strategy. As the monitoring results became available, they could be used to further refine and invalidate the model. This could then be used to adapt the mitigation procedures and suggest management alterations (if necessary). It would also increase the transferability of the analysis to other projects.

4. *Conclusions*

a) *Success*

1. Although AEAM has yet to be tested in this context, the indicators of a successful application of AEAM to EIS would be:

   - a more integrated analysis
   - clarification of the significant issues, identification of the insignificant issues and appropriate rationale
   - an evaluation of alternative options
   - a prescriptive analysis rather than descriptive
   - a coordinated, open assessment with continuity from start to finish
   - an iterative reporting procedure demonstrating the proponent was open to new insights and could adapt and learn as the analysis progressed

2. Success of AEAM is not, at this time, truly predictable within the EIA process. However, given the frustrations currently being expressed in Canada and the U.S., the subgroup was confident that AEAM would radically improve the EIA products and ultimately be considered more successful and satisfying to both the proponent and regulator.

b) *Institutional*

1. People would be very important to the application of AEAM in EIA. The right kind of expertise is critical at all phases, especially in the modelling workshops. It is also crucial to ensure the senior decision makers, convened early in the process, are innovative and aggressive to guarantee the first step is a good one.

2. Generally, the institutional framework is compatible with the application of AEAM in EIA. The one stage where there is some question is the scoping/guidelines stage where the major problem is how to effectively involve the public. Interestingly, the subgroup felt AEAM was institutionally most appropriate at the first (i.e., policy/planning) and last (i.e., monitoring/regulation) stages of the process.

c) *Practiability*

1. Generally, it was felt that using AEAM in EIA would be very cost effective. Since the AEAM process quickly identifies data needs and key issues, subsequent analysis and research would not spend resources on non-critical directions. This of course depends on the degree of acceptance of the rationale for exclusion. A proponent may prefer to spend more money now rather than risk future confrontations. In any case, the solid planning and continuity possible with AEAM should provide many opportunities for savings.

2. Given the dissatisfaction with present EIA methods, it was felt that the procedures of AEAM should be able to get commitment. However, the major obstacle, as in any long term procedure, is getting continuity of commitment. Since an EIA could continue over a number of years, the benefits of the AEAM process would be greatly enhanced if the same expertise/decision makers/reviewers could be maintained over the duration of the analysis.

d) *Delivery*

In EIA applications, both the quality of the product and the packaging of the process are critical to success. Since the number of interest groups is potentially large and, therefore, so is the mix of expertise, a creative combination of reports, workshops, meetings, and communication packages is needed throughout the process to keep all groups informed and involved. This probably represents the biggest challenge in applying AEAM in this context.

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Research Planning

Summary

The effectiveness of AEAM in facilitating the planning and management of research programs is well established. The major result, better and more cost effective research, is delivered in terms of a number of products. The tangible products include: the simulation model, the research plan, and reports; the intangible products include: the development of a common understanding, increased communication amongst researchers and managers, a list of gaps in data and knowledge, and support for the research plan based on consensus and knowledge of its strengths and weaknesses. The success of a research program can be enhanced by using AEAM throughout the course of the program. During the initiation stage, AEAM should be used to help with problem definition and the determination of what and what not to consider. During the operation stage of the program, workshops held at regular intervals should be used to evaluate and redesign research. Finally, it should be used during the termination stage to integrate the results of the program. People are critical in any application of AEAM. Including the right mixture of experienced and creative scientists along with managers and policy makers is necessary to ensure that a credible, rigorous, and usable product is produced. AEAM is extremely effective in ensuring that research is continually evaluated so that it may be adaptively redesigned in response to new knowledge and changing conditions.

These conclusions, which emerged out of discussions with experienced research program managers during the meeting of the research planning subgroup, are reinforced by four case histories. These case histories, chosen to be representative of applications of AEAM to large research programs, are: drilling muds research in the Gulf of Mexico, ecological process studies in the Alaskan Beaufort Sea, environmental studies in the Mackenzie delta, and the integrated wildlife and intensive forestry management on Vancouver Island.

THE RESEARCH PROGRAM MODEL

The central question faced by any group of people charged with the responsibility of planning and managing research is, "can a system (organization) be designed to carry out all the necessary activities of the research program?" These activities, for environmental purposes, range from research planning, data collection and experimentation, to provision of information for the public policy making process. To best understand how AEAM would facilitate the planning and management of research programs, it is instructive to look at the simple model of a

research program (Figure A.3). Typically a research program goes through three stages: initiation, operation, and termination.

During initiation the client's needs become apparent; the problem definition helps clarify what research should be done, detailed designs of specific studies are produced, and data collection begins. Once the detailed designs begin to emerge the operation stage of the program is well under way. The operation phase often proceeds over a number of years. In some programs the feedback loop from evaluation of specific studies to problem definition does not exist. In these cases, the information gathered during one year has little impact on what information is gathered in subsequent years; there is little redefinition of the problem, and little redesign of specific studies. In other programs where the feedback loops are well established, new understanding can be brought to the problem definition, studies can be completely redesigned if necessary, and subsequent data collection enhanced. During the termination stage, data collection activities wind down and more emphasis is placed on analysis and reporting of results.

In this simple model, evaluation is shown occurring each year after the data collection and analysis. In practice, evaluation is ongoing throughout the program but because of its importance, it is included formally in the model to indicate its ability to successfully redirect research.

In the context of this research program model, the procedures and philosophy of AEAM are highly compatible. AEAM's key contribution is to the adaptive redesign of research in response to new understanding that develops during the course of the program. Workshops and modelling are used to continually reevaluate and organize information as it is gathered, thereby synthesizing understanding. These procedures ensure the feedback loop shown in Figure A.3 is operative, and the subsequent research adapts to new understanding and changing conditions. Thus, AEAM has a substantial role to play in both the initiation and execution of a research program.

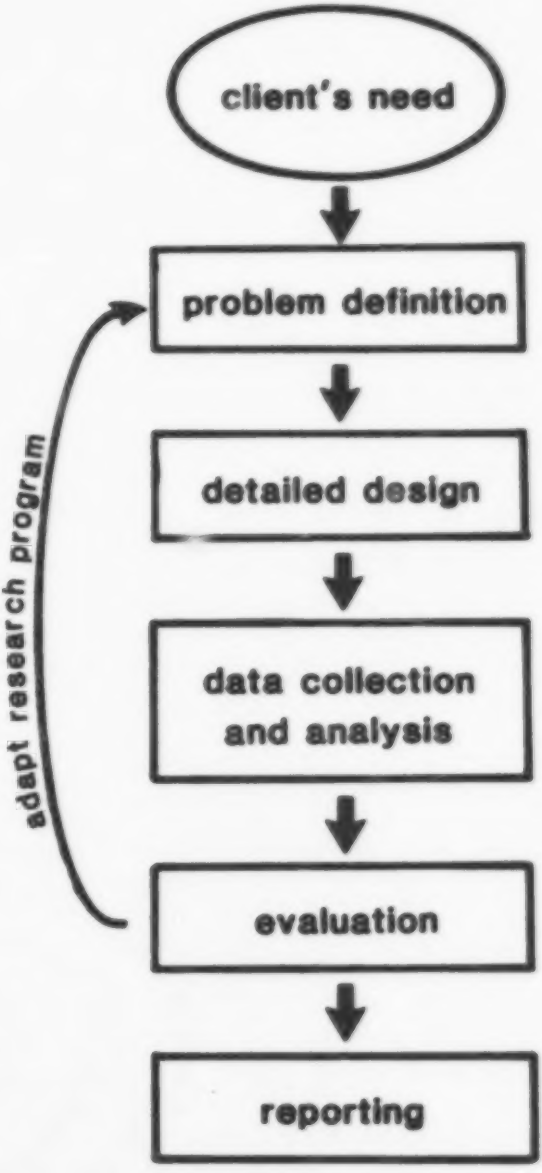
EXAMPLE APPLICATIONS OF AEAM TO RESEARCH PLANNING

AEAM has demonstrated its ability to facilitate research planning in a number of contexts, differing in scope, subject, and geographic location. Critiques of four examples are presented below:

A) *Potential Impacts of Drilling Muds and Cuttings on the Marine Environment.*

This application was sponsored by the U.S. Environmental Protection Agency in conjunction with the research program of its Gulf Breeze

FIGURE A.3.
A simple model of a research program. Within each year the program goes through a series of tasks: problem definition, evaluation, detailed study design, data collection and analysis, and reporting.



Laboratory. Specific objectives were to:

- provide a forum for effective communication between scientists and administrators working with the fate and effects of drilling fluids disposal;
- begin construction of a simulation model to capture the physical and biological dynamics of drilling fluids disposal in the marine environment;
- identify gaps in information on fate and effects of drilling fluids discharged into the marine environment; and
- initiate identification of factors determining fate and effects, which will eventually result in guidelines to assist in permit formulation.

What Was Done

A modelling workshop, with a strong scientific emphasis, was held and a report subsequently produced. Participants were drawn from researchers funded by the Gulf Breeze extramural drilling fluids research program, regulatory and permit review agencies (EPA, FWS, BLM, and USGS), and oil and gas development scientists and engineers. It is important to note that the workshop was held near the end of the research program and one of the underlying objectives was a synthesis of the EPA drilling fluids research program.

Impact on the Research Program

The application was especially effective in providing a forum for meaningful discussion between specialists in various aspects of the problem (e.g., chemistry of drilling needs, hydrodynamics of plumes, toxicology). The workshop allowed EPA and industry scientists to come together with a strong common purpose to establish the extent of environmental risk on an objective basis. This was surprising because the topic of the workshop had been an emotional and polarized issue with substantial restraint and suspicion among the various interests. The workshop and report helped identify gaps in data and understanding, thereby focussing on *what* and *what not* to consider.

B) *Ecological Process Study of Barrier Island Lagoon System in the Beaufort Sea.*

The best example of an application of AEAM as a tool for planning and management through the course of a research program has been the Barrier Island Lagoon project conducted by LGL for the U.S. Outer Continental Shelf Environmental Assessment Program (OCSEAP).

The project was a large inter-disciplinary research program during 1976 - 1980 that was designed to study the ecological process of the Alaskan Beaufort Sea.

What Was Done

A series of workshops, (two a year; one in the early spring, one in the late fall) were held throughout the life of the project. The spring workshops evaluated the current state of knowledge, updated the simulation model, and designed research for the following summer. The fall workshops evaluated the previous summer's research, determined what analysis was needed before the next workshop, and planned the winter studies. During the initiation phase, the first modelling workshop was used to carry out a systematic problem definition; during the termination stage, the workshop served an integrative function by synthesizing the results of the program as well as communicating the results to the client group within OCSEAP.

Impact on the Research Program

Throughout the research program the workshops were continually used to evaluate and organize information. This contributed to an adaptive redesign of field studies in response to new understanding. The modelling helped to determine appropriate spatial and temporal considerations for the research. The development of a common systems understanding through definition of a quantitative model helped decide *what* and *what not* to consider.

C) *Liard River Hydroelectric Development: Mackenzie Delta Modelling Environmental Studies.*

This application, sponsored by the British Columbia Hydro and Power Authority, Environmental and Socio-economic Services, had the following objectives:

- to conceptualize and simulate those physical and biological processes in the Mackenzie Delta which might be affected by flow regulation caused by the Liard River hydroelectric development;

- to utilize the model as a focus for the identification of major conceptual uncertainties and information gaps (i.e., identification of research priorities), and communication of objectives and research priorities to B.C. Hydro, government agency personnel, and consultants;

- to integrate the various study components in a logical and scientific way; and

- to use the model for sensitivity testing to indicate those information needs which would give greatest returns in terms of manpower and budget expended.

What Was Done

The work proceeded in two phases. The first phase was initiated with a modelling workshop held in June, 1980 which developed a model of the biophysical processes in the Mackenzie Delta. This was followed by two field seasons on the delta. The second phase, initiated in January, 1982, integrated the findings of the two field seasons with the understanding developed at the June, 1980 workshop. This was accomplished in three steps. First, a three day workshop was held. The participants consisted of private consultants, scientists and engineers from B.C. Hydro, and scientists and managers from the federal and territorial governments. Second, the workshop was followed by a two week period of intensive modelling. Third, a two day research planning workshop was held. At this workshop, the model was presented and considerable discussion of needed research took place.

Impact on the Research Program

The June, 1980 workshop was held immediately prior to the consultants going into the field. While the workshop identified new areas of research that could be undertaken, some consultants were unable to adapt their field programs to collect the required information. During the 1981 field season new consultants were hired to do studies more in tune with the research objectives. Although the second phase is still in progress, it appears that the workshops have led to a clarification of the information needs about the hydrological changes that may be brought about by the development. In addition, the planning of new research on wildlife and, to a lesser extent socio-economic concerns, has been enhanced.

This series of workshops underlined a key lesson for both the practitioners and the client. The success of the workshop is critically dependent on having the right people as participants. Scientifically incorrect concepts and relationships can develop because of inadequate knowledge and experience on the part of participants. (This underlines the importance of the systematic improvement of models providing feedback to the information gathering process through a series of workshops and model building exercises.)

D) *Integrated Wildlife-Intensive Forestry Research (IWIFR) Program.*

The Integrated Wildlife-Intensive Forestry Research (IWIFR) Program is a cooperative program of the B.C. Ministries of Forests and Environment. It was designed to investigate the effects of second-growth silvicultural practices on wildlife populations. AEAM was used to provide a framework for cooperation and communication between wildlife and forestry concerns, develop a simulation model to use as a guide in designing a research plan for IWIFR, develop a set of hypotheses about the system under study, generate a framework for evaluating the relative importance of different processes, and decide on appropriate spatial and temporal scales for program research.

What Was Done

A modelling workshop was held in January, 1981 with researchers from the provincial Ministries of the Environment and Forests, as well as representatives from private forest companies and public interest groups. Subsequently, a report was produced with a large number of recommendations on needed research. As the workshop was held at the beginning of the research program, it was designed to help produce the overall research plan for the project.

In January of 1982, the second phase of the project began with the pieces (submodels) from the workshop model being extracted, simplified, and transferred to project biologists within the IWIFR program. The objective is to have research people use the model to examine hypotheses and help direct research. There are indications the large synthesis model will be used in the future to integrate findings from all the projects within IWIFR but no formal commitment has yet been made by IWIFR management.

Impact on the Research Program

The IWIFR program was somewhat slow to use the results of the workshop, largely due to not having the proper personnel in place. This has since been rectified and the program has acted upon a large number of the results of the workshop, specifically an extensive review of literature relevant to the model processes and further model refinement. It is not clear at present whether or not the nature of the research would have been any different if AEAM had not been used, but the research on some of the components is definitely in line with the major recommendations of the report.

The model developed during the workshop was spatially complex and hence cumbersome and difficult to interpret. The shift to smaller, easier to understand models is a direct result of the AEAM process forcing

participants to explicitly simplify the system and consider the spatial extent and resolution of the intended research.

GENERAL MODEL OF APPLYING AEAM TO RESEARCH PLANNING

The participants in the research planning subgroup were experienced in planning and management of research programs and all had played some role (either user or practitioner) in the application of AEAM to research planning. In particular, all the applications discussed above were represented by the experience of the people in the sub-group. While the discussions were far ranging, their content can be conveniently grouped under the headings: timing, people, products, and limitations.

Timing

There was a general consensus that the best approach is to follow the example used in the Barrier Island Lagoon study. That is, use the modelling workshops during the initiation stage to help with problem definition, then have workshops at regular intervals throughout the operation stage of the program, and finally use the workshop process to integrate the results during the termination stage.

However, it was argued that the process can be effectively used at other entry points. This was seen to be the case for the EPA research program on drilling fluids and cuttings, where the workshop helped put the program back on track.

People

The choice of people to attend the workshops and participate in the application of AEAM to the research program was seen to be critical. It was felt that the participants should include: the user, the facilitators/modellers, disciplinary specialists from the research team, outside experts (private and government), and in some cases, public interest groups.

The user was thought of in two ways: direct and indirect. The direct user would usually be the research program manager and would work closely with the facilitators/modellers of the workshop team. The indirect user would include senior policy managers as well as sponsoring and outside agencies. The participation and commitment of both direct and indirect users is important if the results are to be credible and useable.

Besides conducting the workshop and building the model the facilitators/modellers should play a key role in selecting the best available

participants for the workshop.

It is important that the disciplinary specialists from the field research team be present since the workshop will help them develop an appreciation of the overall research program and an understanding of how their specific project fits into the overall program. Equally important are outside experts who have special knowledge either because they have done research in the geographic locale or because they have worked on similar systems. They provide a perspective that is often lacking within a research team.

Involvement of the public in research planning applications was seen to be case specific. In some cases the public could offer a perspective that scientists could not bring to the problem; their participation could enhance the credibility and usefulness of the research. In other cases, it was felt public input could detract from the scientific objectives of the program.

Products

The tangible products were seen to be: the simulation model, the research plan, and the report. The simulation model is an essential product because it represents the quantitative understanding of the system under study. The very nature of simulation models facilitates the development and evaluation of project scenarios and the sensitivity analysis of critical assumptions. Also, the model can often help evaluate trade offs that affect the design of research alternatives.

The intangible products include development of a common understanding, increased communication (both lateral and vertical), bridging of credibility gaps between researchers (from regulatory agencies, industry, and government), and knowledge of the plan's strengths and weaknesses. The common understanding that emerges results from explicit definition of spatial and the temporal considerations, from setting the boundaries of what is to be included, and from systematic examination of what is known and not known. However, the critical step in the development of understanding is the systematic analysis of the interrelationships between the myriad components.

Limitations

The major limitation is the difficulty of building a credible model in a single modelling workshop. The model must be refined through an iterative process of model experimentation, data gathering, refinement, more data gathering and so forth.

Another limitation is that although a list of research topics is generated during the workshops, it is usually not possible to provide an objective ranking of them. This acknowledges that the selection of which research is to be done has a subjective element.

Another limitation is people. As was noted in the Mackenzie Delta application, about 25% of the participants did not make a contribution; either because of inadequate knowledge or an inability to express it within the framework demanded by the model building exercises.

CONCLUSIONS

The application of AEAM to research planning can be summarized as follows:

a) *Success*

1. The indicators of success in this context are savings, the quality of the research plan, and the quality of the research. The impact on both the research and the research plan can be viewed in terms of changes, acceptance, quality and review comments.

2. Success is highly probable if AEAM is used at the appropriate time in the research program.

3. AEAM does impact many of the decisions within the research program, especially those regarding the kind of research and the level of effort required.

b) *Institutional*

1. People are very important to the AEAM process as applied to research planning. The right scientific expertise is critical to the quality of the research plan; the right managers and users are critical to credibility and acceptability of the research results.

2. The institutional frameworks of large research programs appear to be compatible with AEAM. The explicit inclusion of the process of AEAM in the research program appears relatively easy to achieve once the commitment is made.

c) *Practicability*

1. Review comments on the Barrier Lagoon studies suggest that AEAM is a cost effective way of planning and managing research as well as ensuring that the research undertaken is cost effective.

There is insufficient data and analysis from other programs to conclude the contrary.

2. Usually it is possible to obtain commitment for applying AEAM to research planning. However, subsequent commitment for continued involvement is often difficult.

d) *Delivery*

1. In research planning applications the quality of the products (model, research plan, and report) are the prime determinants of success. This may be because the research planning applications are already packaged in a style that has proven its worth.

RECOMMENDATIONS

1. AEAM should be used throughout the course of a research program beginning with the first problem definition in the initiation stage. Then it should be used through workshops held at regular intervals during the operation stage. And finally, it should be used during the termination stage to integrate the results of the program.

2. Because of the importance of selecting participants that are knowledgeable and productive, the modelling team should work closely with the user to select the participants for the workshop.

3. Credibility will be enhanced if rigirous reporting is carried out along with peer review. Again, relating back to selection of participants, choosing reputable people will enhance credibility.

4. It is important to ensure accountability and cooperation of the researchers and scientists by involving senior management.

5. AEAM should be used in any program where there is a genuine commitment to improve the quality and cost effectiveness of research.

Resource Management and Policy

Other than in perhaps research planning, AEAM has been used most often in addressing issues of resource management and policy (all five case studies in Holling, 1978 were in this application; see Appendix II for a description of more recent applications). Resource management, in the context of the subgroup discussions and this report, is defined as being geared toward specific users with short term management questions (e.g., annual quotas, level of recreational cottage development). Resource policy deals with larger scale issues with longer time frames and defines broad goals and objectives (e.g., trade offs between concentrating fisheries management effort on slightly acid stressed, insensitive watersheds while writing off heavily stressed lakes and sensitive watersheds, or trying to manage for fisheries and acid stress in all lakes).

The term AEAM has been closely identified with the notions of resource management and policy in three ways:

1. AEAM is adaptive management (experimental management by trial and learning);

2. AEAM is a series of collaborative problem solving methods by which adaptive policies and management decisions can be made; and

3. AEAM is a modelling workshop at which resource policy issues are discussed.

The first definition of AEAM is too broad; adaptive management has historically been used without AEAM and does not require AEAM. The third definition is too narrow; AEAM would be ineffective if it were only a modelling workshop. The second definition is closer to the original definition of AEAM.

A central tenet of AEAM, important in discussing its role in resource management and policy, is that there will always be more unknown about a resource system than known. This means that all policies will eventually fail. The design of many of the popular methods of AEAM (e.g., workshop) takes this uncertainty into account. The question is, are other key elements of resource management and policy, such as institutions, capable of responding to this uncertainty and inevitable policy failure?

Some of the best examples of using AEAM in resource management and policy are the West Coast Fisheries work (Walters et al., 1982), Obergurgl (Moser and Peterson, 1981), and North Dakota Wetlands (Auble et al., 1980).

1. *Elements of Resource Management and Policy Design*

There are elements common to all models for management or policy design. Concomitant to these elements are procedures of AEAM which can be used at each phase of the design process and the benefits that accrue from using those procedures (Table A.1). Two observations arise from this table. First, much of the experience with AEAM has been in the area of definition and analysis of issues and therefore, that is where the procedures are best developed and the benefits most obvious. Procedures of AEAM for other elements of the design process are less well developed and the attendant benefits are not as clear. Second, there is uncertainty as to the ability of any procedure of AEAM to directly generate alternative management policies.

Does AEAM generate creative options for resource management and policy?

Invariably, attendees of workshops express the desire to be able to look at and choose from a range of creative options relating to management or policy design. AEAM is very useful for evaluating options in the context of dynamic systems behavior and the concerns of various interested parties. However, AEAM by itself likely does not generate options. Rather, it creates an environment (e.g., a workshop environment) in which creative options are *more likely* to be generated, and in turn, creates and uses tools (e.g., the model) which can be used to evaluate the alternatives. The North Dakota Wetlands and the Beaufort Sea applications are two examples of this (see Appendix II). Practitioners cannot guarantee that a range of alternative management strategies or policies will automatically come out of a workshop or any other AEAM application. That depends on the participants. Practitioners, though, can certainly claim that the tools of AEAM are designed to stimulate the thinking of participants into modes they rarely use and thereby enhance the possibility that interesting, unusual, perhaps even creative, alternatives will emerge. If they do, they can be easily evaluated using the semi-objective structure of the model.

Can the public be involved?

A recurring theme in assessing the utility of AEAM is the suitability of public involvement in AEAM when used for developing resource management and policy. There are basically two kinds of public that could potentially be involved in AEAM applications:

a) representatives of specific public interest groups; and
b) concerned individuals.

It is unlikely that it will be possible to allow participation of concerned

TABLE A.1.
Elements of any management and policy design process: the procedures of AEAM which can be used in those elements, and benefits of using AEAM in each phase.

Phases of Management/ Policy Design	Procedures of AEAM Which Can Be Used	Benefits of Using Using AEAM
Definition and Analysis of Issues	— workshop — model simplification	— communication is consistent with quantitative framework — focus for debate — identify critical linkages, feedbacks — crips definition of problem
Generation of Alternatives	?	?
Evaluation of Alternatives	— policy workshops, various systems analysis methods (e.g., utility analysis	— policies testable in laboratory world
Communication of Design Process	— audio-visual presentations, nomograms	— use of model as thread of commonality among all roles, institutions and disciplines

individuals in many of the standard AEAM procedures, although this has occurred at times and was successful in that they participated creatively (e.g., the newspaper editor of Jackson, Wyoming; the farmers of Obergurgl). However, their participation is likely to remain the exception rather than the rule since it is difficult to keep participants at AEAM activities to a minimum and there is also the difficulty of contacting the public.

Who would the user invite from the general public? Most public invitees would be invited because they represent groups who will be directly affected by the management strategies and policies developed.

Given that the public will have to endure the consequences of resource management and policy decisions, it is prudent and wise to make sure that the public is involved in AEAM through management and policy design. A standard modelling workshop may not be the appropriate medium for such involvement; other methods, such as simple gaming sessions similar to those used to present the results of West Coast fisheries work (Walters et al., 1982) can be devised and used.

Practitioners of AEAM espouse the necessity to benefit from unexpected events. If this is true, the practitioners and users should not seek stable, unpredictable participants, but should perhaps exploit seemingly unproductive and extreme-minded persons to contribute to developing the range of creative options for resource management and policy.

Responsibilities of the Practitioner

Practitioners of AEAM have been criticized for:

1. promising more from a single workshop than they can deliver; and
2. avoiding implementation of AEAM results.

The first criticism is somewhat justified; the second is unjustified.

Any single application of AEAM cannot bring about all the benefits of AEAM as outlined in Holling (1978). Because of the institutional location of most AEAM practitioners at present (a private consulting firm and a government group with insecure funding), they have, at times, promised more than was actually delivered. Users have often felt frustrated at the difference between promises and products, but were pleased at the quality of what was actually delivered. There has been learning by both users and practitioners as to, for example, what a single workshop can do and cannot do. Users are now better informed before entering into AEAM and practitioners are more knowledgeable about what is possible in each application. The result is that most workshops now include more preparation time, post workshop model refinements, and sensitivity analysis in order to better meet the claims of practitioners.

To decide what can or cannot be accomplished in a prospective application, AEAM practitioners must consider:

a) the institutional nature of the management problem — this defines participants, and perhaps a key person to nurture the AEAM application; and

b) the entry point at which AEAM is being applied — a workshop in the middle or end of a policy design process will invariably frustrate and anger many of the workshop participants.

AEAM practitioners have had sufficient experience with various entry points and institutional structures and can be fairly certain about the potential results of any AEAM application.

The second criticism is unjustified because the responsibility for carrying out the results of an application of AEAM rests not on the shoulders of the practitioner, but with the user and core group. The AEAM practitioners certainly do not have the sole responsibility for designing the policies. They can facilitate interaction between different roles (e.g., scientist, policy advisor, public) and institutions concerned with policy options in terms to which the interested parties relate. But, they must be viewed mainly as independent third parties to policy formulation.

Much of the confusion stems from the separate notions of:

(a) the philosophy of adaptive management; and
(b) the procedures of AEAM.

The former cannot be implemented within an institution from outside; it must be largely learned. The latter can come from the outside or it can be integrated with institutional procedures through a training program. By conducting a few workshops, AEAM practitioners cannot hope to change the management philosophy of an institution. But, the practicing of AEAM within various levels of management can certainly help to change traditional management and policy design processes and introduce adaptive design processes which explicitly acknowledge risk and uncertainty. AEAM practitioners can be used as instruments of change; they cannot be the source of change.

2. *Implementing AEAM in Resource Management and Policy Design*

Implementing the results of an AEAM application has been difficult because the results often suggest a radical shift in policy or management.

It is made even more difficult if the only procedure used is a single workshop. The practitioners are often viewed as uninformed outsiders who come in, upset the normal course of business, frustrate participants, and then leave. Although the responsibility for implementation of AEAM results into actual management and policy ultimately lies with the user and core group, tools such as policy workshops (see also Integration Section, Appendix I) would certainly make implementation easier. The user must show greater commitment than a single application of AEAM. A greater range of AEAM applications for a single policy design problem would also enhance the probability that various institutional levels would become involved in the process and come to feel as owners of the results.

3. *Success of AEAM in Resource Management/Policy Design*

Evaluation of the success of an AEAM application is not appropriate immediately following the specific application. Also, there are varying criteria for success. There does not have to be any change in policy for AEAM to be successful; political or other pressures may prevent a change in policy. An application would be successful if managers and policy people used it to evaluate alternatives thereby examining possible consequences of their policy; or if it made the uncertainties and risks explicit.

The success of AEAM depends partly on the scope of the problems and issues being addressed. AEAM applied to specific, narrowly focused management problems may have a lesser chance of success because

many of the possible sources of surprise lie outside the system being considered. On the other hand, broad policy problems may have a greater chance of success because the possible sources of surprise will tend to be within the system being considered and will therefore be acknowledged as such.

4. *Recommendations and Conclusions*

1. Public participation should be encouraged in AEAM applications geared towards developing resource management and policy.

2. Application of AEAM in management and policy design requires more than a single workshop.

3. AEAM does not automatically generate creative options for management and policy, but applications of AEAM do generate a forum where the likelihood of deriving creative options is enhanced.

4. AEAM is better suited to broad policy questions that are extensive in scope (strategic), rather than narrowly focused problems and issues (tactical).

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Project Integration and Synthesis

The original task of this subgroup was to examine the applicability of AEAM for the task of integration at the conclusion of a research project or impact assessment. Subgroup members quickly realized and agreed that although tools of AEAM, such as modelling workshops, have been successfully applied for such a purpose (e.g., Teleki et al., 1982), the philosophy of AEAM, that of bringing together different institutions, different roles, and different disciplines at the beginning of a project or assessment, limited the discussion topic. Discussions therefore focused on integration from the beginning and throughout a project or assessment.

1. *Task of Integration*

There is no doubt that AEAM, in its various forms (i.e., modelling workshops, systems analysis, etc.), does integrate. Building models in a workshop setting is a proven method of integrating the understanding and concerns of the participants. However, integration usually must occur among three factors:

(a) disciplines (i.e., scientific specialists, economists, engineers, etc.);

(b) people — from the field technician to the policy advisor to the public; and

(c) institutions — either among branches within a single agency or among different agencies.

The integration of any project can be described in terms of sets of these three factors, although bounds must be placed for any single application of the AEAM methodology. A modelling workshop, for instance, must be restrictive in the number of participants. Not all affected parties, institutions, or disciplines can attend. The true question of integration therefore becomes not one of integration within a single activity (e.g., a workshop), but integration of the results into a wider audience of disciplines, roles, and institutions.

Role of the User

The most critical element in the successful use of AEAM as an integration tool is an enlightened user. The enlightened user must:

(a) have the respect of people outside those involved in any particular application;

(b) fully understand the benefits and limitations of the application;

(c) have the power to implement recommendations and results;

(d) fully understand the institutional structure surrounding the particular problem; and

(e) be willing to act as a filter between the AEAM practitioners and participants.

Knowledge of the existing institutional structure and respect of key people in those institutions inevitably makes implementation and acceptance of AEAM results easier.

Users with some of these attributes do exist for most situations. The difficulty is in finding a user with all attributes. In most examples of success, the user has had all the above qualities and has been able to incorporate the results effectively within their own organization. It is interesting to note that success usually did not depend on any set routine or specific presentation device (such as audio-visual packages or model gaming sessions). More often than not, it was simply a case of the user discussing and advocating the results with participants (e.g., Lakeshore Capacity Study, Beluga Coal). The conclusion is that there is no simple formula; each AEAM application will develop its own style.

The role of the user as a filter must not be underestimated. AEAM practitioners cannot be in tune with the day to day institutional opportunities for integration. The practitioners must be seen as persons with the technical and communication skills required to undertake the AEAM process. It is the job of the user to implement the results and take on the institutional responsibilities and consequences of that implementation. The two tasks are very different, demanding different skills, and should be kept as separate as possible.

Role of Random Events

Opportunities for integration to larger audiences are rarely predictable; they often come as complete surprises to the practitioners and users. These opportunities must not be foregone. The users should be aware of any potential mechanisms for integration outside of the original sphere of involvement; they, perhaps together with the practitioners, should respond immediately to these opportunities. Possible responses would vary with the nature of the opportunity. For example, a simple briefing session may be sufficient for a policy advisor; a model gaming session may be required for a technical group within an agency.

Timing

The timing of AEAM activities cannot be fixed. The phenomenon of random opportunities discussed above makes the scheduling of AEAM

activities over the long term unrealistic. Certainly, a single workshop is insufficient. Since part of the AEAM philosophy is learning from research and from different perspectives that come from other disciplines, roles, or institutions, a single workshop or single communication package is inappropriate; further opportunities to integrate must be allowed.

Barriers to Effective Integration

A number of constraints to integration for larger audiences were identified:

(a) irrational commitment to a particular scientific paradigm or policy;

(b) natural reassimilation of persons back into institutions after participating in the AEAM process;

(c) the "closing in of ranks" that occurs to participants after attending a workshop or some other AEAM activity;

(d) the relative novelty of AEAM;

(e) lack of technical ability within the institution; and

(f) user inability to change or work around the above constraints.

It is interesting that the perception of AEAM as a novelty is still a very real constraint. The modelling workshop is tried and true; it works and has obvious benefits. Other tools of AEAM are less proven; users are invariably less willing to commit money and time on something which is less certain to bear useful results. This attitude is changing. AEAM practitioners are generally frustrated with simply doing modelling workshops without any follow up to carry the results to a larger audience. Also, users are beginning to realize the inability of a single workshop to reach and involve all relevant disciplines, roles, and institutions. Again, the user is critical here. Constraints to AEAM integration will inevitably arise in all cases but a respected user should be able to act as an effective spokesperson for AEAM and thereby bring the process to a larger audience.

The lack of technical expertise is not as great a problem as it once was due to the advent of microcomputers. The nature of microcomputers (personal, user-friendly, etc.) makes them ideal tools for transferring models to personnel within institutions. Microcomputers' limited size and execution speed is not a hindrance because practitioners and users are forced to consider only the critical components of a system. This approach is being used more and more and is proving very satisfactory

(e.g., IWIFR, Great Lakes Fishery Commission). Again, there must be commitment and desire within the institution to receive the model and use it.

2. *How to Integrate Using AEAM*

Given a strong user, how can he, along with the practitioners, communicate to a larger audience? This is, in essence, the issue of creative packaging.

Workshop Reports

Workshop reports are often the only lasting evidence that AEAM was ever used on a project. They are glorious tomes, with detailed descriptions of the model, scenarios, and a summary of workshop proceedings. Executive summaries are quickly written and often inserted at the very end of the report production phase. In addition, the report is usually written only by the practitioners with little guidance from the user.

The user should be more closely tied to the report writing. The user is more in tune with the institutional make-up in which the report will be received and can give valuable insight on how to tailor the report for participants and, more importantly, sections of the larger audience.

Second, three or more reports should be written, each aimed at different audiences. The detailed report presently written should be maintained. However, there should be a series of shorter summaries, such as carefully constructed abstracts and executive summaries, aimed at people not participating in the workshop. For example, policy advisors who are interested in the results of a workshop may not be able to attend the workshop or read a 100 page technical monograph. They should be given a succinct written summary. Here again the user could help the practitioners in preparing the other reports.

Audio-Visual Communication Aids

Audio-visual communication packages are the quickest method of informing people about the results of an AEAM application without including all the model detail. These packages are also surprisingly amenable to a wide variety of audiences. However, they must never be viewed as a final unalterable product. Understanding, models, participants, and users change; the communication packages must continually reflect these changes.

Day to Day Routine

The user can bring about successful integration to a larger audience by simple day to day conversations during the normal course of business.

This has resulted in better acceptance of the recommendations and results of the application in, for example, Obergurgl, Lakeshore Capacity Study, and Beluga Coal. It may take a longer time for the results to become apparent but, ultimately, the application may be more effective. Again, the perceived stature of the user in relation to his/her peers is crucial.

Peripherals

Workshops, model gaming sessions, and other structured AEAM activities are usually directed to a few specific objectives. Most participants at these exercises are there to help meet the particular objectives. However, persons not directly connected with the specific problem(s) being addressed, often should be invited to attend all or a portion of the activity to learn about what AEAM is providing. That way, they become sensitized to the process and will be more receptive to integrating the results of AEAM within their own organizations.

3. *Criteria for Successful Integration*

It is extremely difficult to define rigorous, quantitative methods for deciding whether or not integration of AEAM is achieved. There are obvious signs, such as better focused research or policy changes. Others are more subtle.

Perhaps a good indicator of whether or not integration will take place and be successful is the nature of the user. If they have the qualities outlined above, integraton is much more likely to occur (certainly the practitioners would feel better about a user with those qualities than one without) and be successful.

The institutional and disciplinary make-up of participants at a series of AEAM activities (e.g., workshops, communication devices) on any one project should change over time. This is a sign that the nature of the problem and the objectives of the application are changing. If this does not occur, it will be very difficult to ultimately transfer the results to other parts of the institution and especially to other institutions.

Integration can be termed a success if the results of AEAM become internalized. Some signs of internalization are:

(a) an institution comes to recognize a model as its own;

(b) the results of AEAM (e.g., a suggested change in policy or research plan) are implemented and said to come from within the workings of the institution rather than a direct result of AEAM; and

(c) AEAM practitioners are used less and less during the course of, and after, a project.

It is difficult for AEAM practitioners to accept internalization as a sign of success but such phenomena are indicators that institutions and persons within those institutions have accepted AEAM and recognize sufficient merit in it to use it as a regular part of doing business.

4. *Recommendations*

The recommendations from the discussions above are:

(a) Begin the integration process at the start of a project.

(b) Capitalize on every possible opportunity to integrate and be imaginative in creating opportunities and designing methods to achieve integration.

(c) Be patient when integrating. Most institutions will adapt to new innovative ideas and policies but will only do so very slowly.

(d) Educate the user as to:
   i) what a specific AEAM application will and will not do, and
   ii) what the role of the user should be.

(e) Use workshops more than once on a project. Integration will occur more readily with continued interinstitutional and interdisciplinary contact focused toward a specific task.

(f) Tailor each AEAM application to the specific nature of the institutional and disciplinary mixes, as well as type and history of the problem.

APPENDIX II

Application Summaries

As part of the evaluation procedure, the practitioners were asked to prepare summaries of each AEAM application in which they were directly involved. In preparing these summaries they were asked to stress:

- the objectives of the report
- the style of delivery
- the major results

In the interests of brevity, we have exercised our editing license and summarized the summaries. Our apologies in advance for any errors or omissions that may have occurred as a result. The reader is encouraged to contact the relevant practitioners or the user for further information on any one of these applications.

It should be noted that these summaries represent AEAM applications facilitated primarily by ESSA Ltd. and the USFWS-AEA team in Fort Collins, Colorado. Other applications, primarily carried out by the group at the University of British Columbia, are not included.

Sacramento-San Joaquin Water Management Project

Client: California Water Policy Center (CWPC), U.S. Fish and Wildlife Service, Sacramento, California.

Objectives: 1) develop a common understanding of fish and wildlife problems as related to system-wide water resources.

2) set practical bounds for development of a methodology for making system-wide analyses appropriate to Fish and Wildlife responsibilities.

Delivery: a five day workshop, model evaluation workshop, demonstration workshop and a number of technical meetings were held in the period April, 1979 to July, 1981. This was a joint effort between the FWS team and ESSA.

Results:
Four subsystems were represented in the model: hydrology, fish, land use and waterfowl. After considerable refinement, the model received support from a number of federal and state organizations. A number of policy meetings were held using the model as a major focus. These meetings succeeded in developing a more integrated perspective of the basin issues and also generated institutional and monetary support. The model is now under the care of the USFWS-AEA team and is proceeding through further development of the hydrology and fish subsystems.

Environmental Consequences of Beaufort Sea Hydrocarbon Development

Client: Environmental Protection Service; Environment Canada

Objectives: 1) identify key issues of environmental concern in Beaufort Sea oil and gas development.

2) identify critical uncertainties about environmental consequences of Beaufort Sea hydrocarbon development.

3) identify features of Beaufort Sea development that could be modified to ameliorate environmental effects.

Delivery: a four day workshop and report. The workshop, conducted in Vancouver, B.C. in March, 1981, was attended by representatives from various federal government and territorial agencies, private consultants, and the oil industry.

Results:
A set of environmental uncertainties and potential development modifications were generated and some adaptive industrial development and management strategies were constructed. This application did not proceed past the first workshop making further evaluation difficult.

Training in Adaptive Environmental Assessment and Management

Client: Great Lakes Fishery Commission (GLFC); Ann Arbor, Michigan.

Objectives: 1) train personnel within GLFC in the principles and procedures of AEAM.

2) provide technical support to the GLFC team in conducting a series of workshops on problems of concern to GLFC.

Delivery: training occurred at a seven day workshop in Vancouver, B.C. in May, 1981. All participants were scientists and decision makers within GLFC. A seven day workshop on sea lamprey control was also held with ESSA assisting as back up in Sault Ste. Marie, Michigan in October, 1981.

Results:
Approximately 7 persons out of 20 trainees were deemed to be sufficiently trained at the end of 7 days to conduct an AEAM workshop.

The sea lamprey workshop was conducted by the trainees with very little support needed from ESSA. There were some difficulties in using microcomputers for linking submodels and debugging; the weekend was needed by the GLFC staff to accomplish these tasks.

Participants were generally enthusiastic about the workshop and there are plans to conduct more workshops on other problems with which the GLFC is concerned.

Western Spruce Budworm

Client: Canada/U.S. Spruce Budworms West Program (CANUSA), U.S. Forest Service, Portland, Oregon.

Objectives: 1) integrate available data and understanding of the western spruce budworm/Douglas fir system into a simulation model.

2) use the model to define important research needs for the 5 year CANUSA program.

3) promote communication among CANUSA research scientists and Forest Service and forest company managers.

Delivery: a five day workshop held in January, 1980 followed by a workshop report.

Results:
The specific workshop application was a success; most participants felt immediately after the workshop that all three objectives had been achieved. The longer term effects, save for the communication, are apparently negligible. There have been a number of attempts to use the model to direct research; these have been moderately successful (in spite of an inordinately large proportion of program money being allocated to a few projects, the validity of which are questioned by the modelling results and other program personnel). Severe budget restrictions have crippled any attempts to have formal model refinement meetings since the workshop, although some loosely structured attempts have been made.

Application of AEAM to Fisheries Management in the Algonquin Assessment Unit

Client: Ontario Ministry of Natural Resources (OMNR); Toronto, Ontario.

Objectives: 1) apply AEAM to a specific fisheries management problem in Ontario.

2) evaluate potential of AEAM in OMNR for research planning, information synthesis, intra- and inter-agency communication and policy analysis.

3) evaluate feasibility of training OMNR personnel in the tools of AEAM.

Delivery: a five day workshop conducted in Orillia, Ontario in December, 1981. The workshop was attended by representatives from the Canada Department of Fisheries and Oceans, Ontario Ministry of the Environment, and OMNR. A second 3 day workshop in 1982 focused on research needs.

Results:
OMNR did gain sufficient experience and exposure to AEAM to evaluate its utility, and recommendations are presently being made by the client to the ministry.

After the first workshop, the somewhat cumbersome model developed by the workshop was simplified and refined. The result was a useful tool that greatly facilitated identification of research needs and interagency communication. The second workshop successfully developed and discussed major areas of uncertainty and the resulting report has since helped OMNR to priorize future research effort.

Currently, primarily due to budget constraints, OMNR has decided to hold on any further training of their personnel in the AEAM procedures. However, use of the model and development of other supporting models is currently being pursued.

Research Planning for the Integrated Wildlife-Intensive Forestry Research Project (IWIFR)

Client: Technical Working Group of IWIFR, British Columbia Ministries of Forest and Environment; Victoria, B.C.

Objectives: 1) develop a framework for cooperation between wildlife and forestry concerns.

2) develop a simulation model to use as a guide to develop a research plan for IWIFR and integrate project research.

3) provide a framework for evaluation of the importance of different system processes.

Delivery: Phase I. A five day workshop conducted in January, 1981.

Phase II. Transfer of submodels to microcomputers and implementation in project biologist field offices; from January to July, 1982.

Results:

Phase I was highly successful in meeting all objectives, at least in the short term. Program management has acted upon many of the key recommendations from Phase I, particularly literature reviews and further modelling. Field research is very similar to Phase I recommendations although it is not clear whether the nature of the research would have been different if AEAM had not been used.

Phase II is also proving to be successful. Program biologists are beginning to use the simpler models, largely to examine their understanding of systems dynamics rather than to modify research.

A potential future difficulty may arise if the individual submodels are not re-integrated into a larger synthesis.

Truckee-Carson Rivers Water Quality Assessment

Client: U.S. Geological Survey; Carson City, Nevada.

Objectives: 1) establish effective communication between the USGS Assessment project and other members of the resource community.

2) involve decision makers, planners, and scientists at the beginning of the assessment to ensure relevance of the project.

3) identify research priorities, data gaps, and information needs for the assessment.

4) provide a means for communicating assessment results to water resource managers and planners.

Delivery: two workshops held in October, 1978 and December, 1979, and three technical meetings aimed at submodel refinements between the workshops.

Results:
The USGS objectives defined for the AEAM work were met very successfully, particularly in the quick interagency communication and rapid education of the assessment team to the complex resource management issues. Research priorities were identified and undertaken as field projects.

Problems arose in that expectations appeared to have been raised for the workshops being able to resolve issues they were not intended for. These issues relate to long standing, often bitter, disputes over increasing demand for a diminishing water supply in the area. The narrow focus of the above AEAM objectives became lost in larger questions of water allocation and management.

Integration of the Lakeshore Capacity Study

Client: Ontario Ministry of Municipal Affairs and Housing; Toronto, Ontario.

Objectives: 1) integrate 5 years of research findings undertaken by three government agencies into a management tool for assessing lakeshore cottage subdivision in Ontario.

2) promote experimental resource management rather than the traditional, after the fact remedial approach.

Delivery: two workshops separated by about four months of model refinements and technical meetings. An initial draft report was prepared after the first workshop and a final report was written in collaboration with the client after the second workshop. A series of overheads and slides describing the model were made for the client.

Results:

This application was different in that it was implemented after the research had been completed. At first, the participants were apprehensive and felt threatened by a perceived challenge to completed research. However, an active and understanding client helped to allay many of these fears so that the participants at the second workshop were generally supportive of the model and how their research was integrated.

The model has been successfully transferred to the client and has received the support of senior policy makers in the Ministry. Efforts are now being made to use the model to help evaluate proposed cottage developments.

Effects of the Alberta Oil Sands Development

Client: Alberta Oil Sands Environmental Research Program (AOSERP), Alberta Environment,

Objectives: 1) synthesize existing AOSERP information.

2) delineate important connections between AOSERP study components.

3) recommend approaches to environmental management in the oil sands area.

Delivery: two workshops, interspersed with technical meetings and model refinement over a 12 month period from October, 1979 to October, 1980 in Edmonton, Alberta.

Results:
A simulation model encompassing the hydrology, fish, wildlife and socio-economics of the oil sands region was developed. Building the model succeeded in integrating the AOSERP studies and identified some major issues that needed further consideration. The workshops and model served as a framework to help in the preparation of the AOSERP five-year summary document presented to the Minister of Environment in 1981.

Assimilative Capacity of Aquatic Environment for Pulp Mill Effluents

Client: B.C. Council of Forest Industries (COFI)

Objectives: 1) evaluate the capacity of aquatic environments to accept pulp mill effluents.

2) establish research needs that would improve our understanding of the effects of pulp mill effluent on marine and fresh-water organisms.

Delivery: a four day workshop held in Vancouver, B.C. in November, 1979. Participants at the workshop represented DFO provincial government agencies, numerous forestry companies, and private consultants.

Results:
The major result was the development of a good research design. The workshop discussion, in conjunction with solicited reports from each participant, provided a solid structure for future research effort. This structure was eventually used to help allocate COFI research funds.

Nam Pong Environmental Management Research Project

Client: Mekong Secretariat, U.N. Bangkok, and Ford Foundation.

Objectives: 1) train Thai scientists in the process of Adaptive Environmental Assessment and Management.

2) develop an integrated impact assessment methodology appropriate to planned development on the Mekong River.

3) develop a management oriented model of the Nam Pong River basin for use by the managers and institutions responsible for Nam Pong basin management.

Delivery: two one-month workshops (October, 1980; April, 1981) held in Thailand, separated by a six month period of model refinement and report preparation. The first workshop focused on training and used the Nam Pong project as a case study. Thai scientists refined the model, and the second workshop concentrated on model evaluation and preparation of the final report.

Results:
The project was successful in training a group of Thai scientists in the principles and techniques of management modelling. However, it is not known whether they could execute a similar case study on their own, since, at the completion of the report writing, most of the trainees had to leave the Secretariat and return to their original employers. Future contact is uncertain.

A working management model of the Nam Pong basin was constructed and refined using microcomputer technology. Although this made model execution slow, the portability and low cost of the microcomputers made them an ideal choice for this application. The model has been transferred to the university located in the Nam Pong basin and efforts are being made to incorporate it into the local decision making structure.

Industrial Development around Mobile Bay, Alabama

Client: U.S. Environmental Protection Agency

Objectives: 1) identify major factors of economic development as related to growth in the Mobile Bay area.

2) identify major environmental issues associated with this growth.

3) identify the relationships between economic and environmental processes in the area.

Delivery: a five day workshop and follow up report held in the fall of 1981. Workshop participants represented local government and community groups, state and federal agencies, and private consultants concerned with offshore drilling.

Results:
The workshop identified the major factors of economic development impacts on other sectors of the economy, and possible conflicts between development in various sectors. Although no new environmental impacts were identified, the possible environmental effects of projected development were explored. The increased understanding among participants on the relationships between components of the economic and resource issues was the greatest benefit of the project.

Resource Development and Management in Jackson Hole, Wyoming

Client: Wyoming Game and Fish Department; Cheyenne, Wyoming

Objectives: 1) promote communication among agencies and interests concerned with elk management in the Jackson Hole area.

2) derive a common understanding of the impact of potential agency policies on the Jackson Hole elk herd(s).

3) increase awareness of the effects of increasing human use in the Jackson Hole area on the management of elk and other wildlife species.

4) identify promising alternative solutions to the elk management problem.

Delivery: a five day workshop held in late 1980, and follow up report, completed by early 1981. The workshop was attended by participants representing local community groups and state and federal resource agencies.

Results:
The project met the first three objectives, especially in the communication between local interest groups and higher level government agencies.

Unfortunately, the fourth objective was not met. This is because of funding cutbacks and, more importantly, because no one agency has sole responsibility for management of the elk herd. Further work to meet the fourth objective and to maintain the progress made in achieving the first three objectives will likely not occur in the near future because of funding limitations and current agency positions on elk management.

Development of the Beluga Coal Resource in Alaska

Client: Biological Services Program, U.S. Fish and Wildlife Service; Anchorage, Alaska.

Objectives: 1) encourage communication among those concerned with development in the Beluga area.

2) promote a common understanding of the scope of development in the Beluga area.

3) promote a common understanding of the legal and institutional responsibilities in the planning and development process.

4) identify information needed and agencies required to provide that information.

Delivery: a five day workshop and follow up report held in summer, 1981. The workshop was attended by state and federal regulatory agencies, local government, community and native groups, and representatives from private industry.

Results:
The workshop succeeded in promoting effective communication between concerned parties, especially in the airing of native concerns. Since the workshop, the Alaska Coal Task Force has been expanded to include federal agencies and native groups and has organized working groups similar to workshop submodels.

The experimental research management schemes suggested at the workshop and in the report may be undertaken but there is no indication at present that they will.

During the workshop, private industry representatives were openly suspicious about FWS motives in sponsoring and apparently facilitating the workshop and the workshop procedure itself. The private interests never really become supportive of the efforts of the staff or other participants.

Potential Impacts of Fluids Generated by Offshore Drilling Rigs on the Gulf of Mexico Marine Environment

Client: U.S. Environmental Protection Agency; Gulf Breeze, Florida.

Objectives: 1) promote communication between scientists and administrators working on effects of drilling fluids disposal.

2) build a simulation model to capture the biophysical dynamics of disposed drilling fluids in the marine environment.

3) identify information gaps on the fate and effects of drilling fluids.

4) identify factors determining fate and effects of drilling fluids to be used in setting guidelines for permit formulation.

Delivery: a five day modelling workshop and follow up report. Participants represented scientific expertise, regulatory and permit review agencies, and hydrocarbon development interests. The workshop was the culmination of a long preparation period for the work which began in early 1980.

Results:
The first objective was met very successfully. Also, all other objectives were met and addressed to various levels of satisfaction in the project.

Participants were resistant to addressing the fourth objective. The inability to consider well permit decisions or research directions may be, in part, due to a long preparation phase and the fact that the workshop was held late in the research project.

Saval Ranch Research Design, Integration, and Synthesis

Client: U.S. Bureau of Land Management; Washington, D.C.

Objectives: 1) iteratively synthesize existing information about the Saval Ranch biophysical and economic systems.

2) develop a simulation model for testing scientific hypotheses and management actions.

3) iteratively determine model development priorities to focus future research, data analysis and monitoring activities.

4) evaluate the potential for applying Saval Ranch project results to other range management cases.

Delivery: a five day workshop held in November, 1981, followed by model refinements, a second workshop in January, 1982, and a report. Three more workshops interspersed with model refinement periods are planned for the remainder of the consultant contract.

Results:
The first three objectives were achieved. Cooperation among project participants has been greatly improved and a model representative of the Saval Ranch system has been built. Immediate research needs and an evaluation of the coming season's field programs were also generated.

Effort is now being made to simplify parts of the model to fit on a microcomputer. The objective is to make the models more accessible to the researchers so they can use and refine the models while in the field.

Impacts of Acid Precipitation on Fresh-Water Fisheries

Client: National Power Plan Team; U.S. Fish and Wildlife Service, Ann Arbor, Michigan.

Objectives: 1) promote communication among principal investigators of acid precipitation impacts on fresh-water fisheries.

2) identify critical research and monitoring needed to assess these impacts.

3) provide a framework (i.e., the model) for integrating research results and exploring potential impacts.

Delivery: a series of modelling workshops held from October, 1980 to the present involving primarily scientists engaged in acid precipitation research.

Results:
Participants agreed that the workshops were a timely and cost effective means of initiating communication and coordination among researchers, integrating NPPT activities with other academic and government agencies, identifying research needs, and providing a framework to integrate research. Many workshop participants recommended further model development and integration of watershed data collection for model testing.

Unfortunately, the National Power Plant Team has since been disbanded and the possibilities for future development are unclear. There is some indication that the U.S. Environmental Protection Agency may request further effort.

Liard River Hydroelectric Development Environmental Studies

Client: B.C. Hydro; Vancouver, B.C.

Objectives: 1) develop an understanding and a model of biophysical and social process in the Mackenzie Delta as related to flow changes caused by the Liard hydroelectric development.

2) use the model to identify major conceptual uncertainties and information gaps and to communicate objectives and research priorities to B.C. Hydro and government agency personnel and relevant consultants.

Delivery: Phase I — a five day modelling workshop conducted by ESSA in June, 1980 and a report of that workshop.

Phase II — two meetings held in February and March, 1982 and a report of those meetings. The first meeting was to refine the Phase I model; the second was to present the computer model and define research needs. The meetings were separated by two weeks of programming time. Both phases drew from field work done the previous year.

Results:
All objectives were met for Phase I, although the Phase I workshop was held too near the field season to have any large impact on that year's research. Also, particular components of the delta system were difficult to address in a rigorous fashion because of the absence of information and/or conceptual understanding.

Phase II was structured as two shorter meetings as an experiment. It succeeded in that the model was conceptually more sound by the second meeting than what would have been otherwise constructed. The Phase II workshops served as a framework for development of the 1982 field season objectives.

Wetland Preservation and Protection in North Dakota

Client: Cooperative agreement between the Assistant Secretary for Fish, Wildlife and Parks, and the Governor's Office, North Dakota.

Objectives: 1) identify alternative strategies for preserving and enhancing waterfowl production habitat.

2) identify opportunities and constraints associated with those alternatives.

3) promote communication and understanding of the implications of these alternatives for all affected parties.

Delivery: a five day workshop and follow up report held from September, 1980 to January, 1981.

Results:
The workshop met all its objectives, and workshop participants agreed at the workshop that this was indeed the case.

However, there were post-workshop efforts by some middle managers to thwart the identified alternatives and negate any enhanced communication. In the short term, this was a hindrance to further progress. Eventually, this counter implementation attitude was successfully neutralized and the activity is now being evaluated for further support.

Development and Application of a Site Selection Methodology for a Liquid Natural Gas (LNG) Facility on the Coast of British Columbia

Client: Petro Canada; Calgary, Alberta

Objectives: 1) design and apply an analytic framework to evaluate potential sites for a West Coast LNG facility.

Delivery: a series of meetings to support a site selection study for Petro Canada. The methodology that was developed and applied integrated the component studies being done by other consultants.

Results:
The design of the framework was achieved. The project integrated the component studies into a model that could be used to assess the relative suitability of a number of sites. It also allowed the client to see the need to trade off various concerns: safety, economic, environmental, and socio-economic. The resultant analysis was used as the basis for the final site selection report submitted to the B.C. Natural Gas Allocation Process.

APPENDIX III

Workshop Participants

List of Participants Attending AEA Review Workshop Jan. 26-28, 1982
Parksville, B.C.

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